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## Section of Epidemiology and State Medicine

President—J. D. ROLLESTON, M.D.

[May 25, 1934]

### The Association between Mortality and Density of Housing

By PERCY STOCKS, M.D.

#### MORTALITY AND DENSITY OF POPULATION PER ACRE.

IN common with most of the fundamental problems of vital statistics, the problems which form the subject of this paper first emerged from the primeval chaos of untested hypotheses under the wizard touch of John Graunt, who wrote [1] in his *Natural and Political Observations*—

"... It follows, therefore, from hence, what I more faintly asserted in the former chapter, that the country is more healthful than the city; that is to say, although men die more regularly and less *per saltum* in London, than in the country, yet, upon the whole matter, there die fewer *per rata*; ..."

A century later Dr. Price gave more precise expression to the penalty which men pay for their astonishing aptitude for leaving untenanted the open spaces of Nature and crowding themselves together in towns, for in an essay [2] published in 1775 he wrote—

"... It may be stated in general that whereas in great towns the proportion of inhabitants dying annually, is from 1 in 19 to 1 in 22 or 23, and in moderate towns from 1 in 24 to 1 in 28; in country parishes and villages, on the contrary, this proportion seldom exceeds 1 in 40 to 50."

The opportunities afforded by the Census, which made it possible to measure population densities per unit of land area, and by the beginning of National Registration of deaths, were quickly turned to good account by William Farr, who in the First Annual Report of the Registrar-General [3] in 1839, made a comparison between the numbers of deaths registered from the middle of 1837 to the middle of 1838 in the Metropolis and in the five south-western counties, which had populations approximately the same. The death-rate in London was 50% higher than in the five counties, the density per square mile being 115 times as great. He then combined London with 24 large towns, and the south-west counties with 8 other rural counties, and produced a table demonstrating that the excess in urban mortality was relatively greatest for respiratory and contagious diseases, and he made the following observation—

"... The occupations in cities are not more laborious than in agriculture, and the great mass of the town population have constant exercise and employment; their wages are higher, their dwellings as good, their clothing as warm, and their food certainly as substantial as that of the agricultural labourer. ... The source of the higher mortality in cities is, therefore, in the insalubrity of the atmosphere."

Farr returned to the subject in greater detail in the Fifth Annual Report of the Registrar-General for 1841 [4a], in which he compared the mortality for the four years (1838-41) in the same areas as before. The conclusions which he reached in this classic of public health literature are no doubt familiar to my immediate listeners, but for the sake of others who may read this paper I will quote a few paragraphs. Having commented in turn upon the command which town and

country people had over the necessities of life, the effects of soil, atmosphere, climate, seasons, winds, temperature, hygrometricity and electricity, and having decided that these were not causes affecting the health of town dwellers unfavourably, he wrote—

“ . . . There remains another class of causes—atmospheric impurities, organic matter undergoing decomposition, and the contagious principles of zymotic diseases . . . ” “ Every population throws off insensibly an atmosphere of organic matter, excessively rare in country and town, but less rare in dense than in open districts; and this atmosphere hangs over cities like a light cloud, slowly spreading, driven about, falling, dispersed by the winds, washed down by showers . . . ”

This atmosphere, he said:—

“ . . . is sufficient to impress its destructive action on the living . . . to connect by a subtle, sickly, deadly medium, the people agglomerated in narrow streets and courts, down which no wind blows, and upon which the sun seldom shines. . . . ” “ It is to this cause, it appears to me, that the high mortality of towns is to be ascribed. . . . ” “ The relation exists strictly between the density of the organic particles suspended in the atmosphere and the mortality. . . . ”

He then proceeded to compare the 1838-41 mortalities of the thirty Metropolitan districts with their population densities per square mile, and deduced his well-known relation of mortality to the sixth root of the density.

In the Sixteenth Report of the Registrar-General for 1853, Farr adopted another method of demonstrating the association of mortality with population density, which was repeated in the Supplements to the Twenty-fifth and Thirty-fifth Reports [5]. This consisted in sorting the districts of England and Wales into groups having a mean annual mortality rate per 1,000 during the decade of 15, 16, 17 and so on, finding the average population density per square mile in each group of districts and showing that it increased with each upward step in the death-rate. A curve drawn through these mean densities gives a sort of regression curve of density upon mortality, but it really does not tell us what was the nature of the converse dependence of mortality on density, which could only be ascertained by grouping the districts according to their densities and finding the mean mortality rate for each group. The conclusion to be drawn from the calculation in the Supplement to the Thirty-fifth Report is not that mean mortality varied as the eighth root of the density, as sometimes stated, but that mean density varied as the eighth power of the mortality, which is not necessarily the same thing. Unless two variables are highly correlated the two regression lines may be widely divergent and may be of different form, and though we are not strictly dealing with regression lines here, we are approximating to them.

In order to compare the relation of child mortality to density per acre at a period before the Public Health Act with that at the present time, I have re-sorted the 593 districts excluding London, which Farr used, according to their densities, and then calculated the mean annual death-rates at ages under 5, and also at all ages, in 1861-70, for groups with density, in persons per acre, under 1, 1 and under 2, 2 and under 3, and so on. The result is shown in Table I, and a few moments' work with logarithms shows that if mortality at all ages be supposed to increase as the  $n$ th root of the density, this inverse arrangement of the data leads to a value near to  $n = 14$ , instead of  $n = 8$ , as suggested by the other arrangement.

TABLE I.—MORTALITY IN GROUPS OF AREAS ARRANGED ACCORDING TO THEIR DENSITY PER ACRE.

Persons per acre	Mean rates per 1,000, 1861-70		Per 1,000, 1890-32 Ages 0-5	Percentage fall Ages 0-5
	All ages	Ages 0-5		
0-	20-29	52.8	15.3	71
1-	21.42 } 22-29	72.6 }	19.0 }	77
2-	23.36 }	78.1 }	16.1 }	
3-	24.24 }	82.5 }	19.2 }	76
4-	22.43 }	77.0 }	19.0 }	
5-	24.74	85.0	16.9	80
10-	26.26	86.6	19.2	78
20-	27.33 }	94.3 }	23.5 }	73
30-	22.61 }	66.0 }	27.5 }	
40 and over	29.30	103.5	28.1	73

The same table shows the mean death-rates at ages under 5 in 1930-32 obtained when the separate county aggregates of urban and of rural districts, and separate county boroughs, are grouped according to their population density in 1931, omitting London as in the data for 1861-70. At densities under 1 per acre, into which category fall most of the rural aggregates, the present rate is 29 per cent. of what it was before the Public Health Act, at 1.3 per acre it is 23 per cent., at 3.5 per acre 24 per cent., at 5-10 per acre only 20 per cent., at 10-20 per acre 22 per cent., and at over 20 per acre 27 per cent., that is to say the relative improvement has been greatest at 5-10 per acre, comprising the present urban districts in the main. It is rather surprising to find that the ratio of mortality at the high densities to that at the low densities remains almost unchanged, but there has been in progress a levelling out of mortality risks at all densities under about 10 per acre. Thus, the child mortality rate at 0.5 per acre is now 17.0, and at 5-10 per acre 16.9, which shows that crowding of houses together up to an average density of 10 people living per acre has now no apparent effect on the mortality of children, but at average densities over 20, that is, in most of the present county boroughs, the relative excess in mortality is as evident as it was 65 years ago, improvement having proceeded at the same rate at the two extremes.

Farr himself foresaw such changes when he wrote in the Supplement to the Twenty-fifth Report of the Registrar-General:—

"... there can be no doubt that mere proximity of the dwellings of the people does not necessarily involve a high rate of mortality... the evils which now make dense districts so fatal may be mitigated. Indeed some of the dense districts of cities are in the present day comparatively salubrious."

When Dr. Ogle repeated, in the Forty-fifth Report, the analysis of densities per acre when districts were grouped according to their mean mortality in 1871-80, he noticed a change in the run of the figures, for at the lower rates of mortality there was no consistent change of density with death-rate, but this was partly due to differences in age of the populations concerned, for Dr. Tatham showed in the Supplements for the next two decades [6] that if standardized rates were employed, the relation with density became evident throughout the range.

#### INTER-RELATION OF URBANIZATION AND GEOGRAPHICAL POSITION WITH DENSITY OF OCCUPATION OF HOUSES.

With the classification of local areas, for purposes of vital statistics, into the categories county boroughs, other urban districts, and rural districts, the density factor has become a commonplace in its reaction on death-rates, but I am not sure that there has been any real understanding of it or as to whether we are overcoming its effects. Are we in a position to improve very greatly on Farr's conception of 90 years ago as to how the association arises? Can we say, for example, after these 95 years of national vital statistics whether, given the same conditions of urbanization, housing and occupation, a person would have any poorer expectation of life if residing in the North of England than in the South West? Or can we say which is the more important in its effect on the risk of death, the number of houses crowded in an acre or the number of people crowded in a house?

We have become accustomed to read year by year that the mortality risk increases as we move northwards in each class of area, and the natural suggestion is that this is due to colder climate, more smoke, more occupations and industries which are dangerous to health, or to a combination of all these. It is a significant fact, however, that if we divide up Great Britain into successive zones of latitude bounded by 50° N., 51° N., 52° N., and so on, omitting London, then as we

move northwards there is a progressive increase in the mean density per room for the population living in those zones until we reach the zone 55-56°, the Scottish industrial area, where the density has reached a level 86 per cent. higher than in the southernmost zone. This is shown in Table II. The density per acre, on the other hand, has its highest value when we reach the zone 53-54°, which includes the industrial area of Lancashire and Yorkshire, and then steadily declines on passing further north.

TABLE II.—MEAN DENSITIES PER ROOM AND PER ACRE IN ZONES OF LATITUDE.\*

		50°.	51°.	52°.	53°.	54°.	55°.	56°.	57°.	Total
Persons per room, 1931	Great Britain:									
	Excluding London†	0.708	0.771	0.762	0.849	1.014	1.318	1.164	1.031	
	England and Wales:									
	Including London†	0.708	0.827	0.762	0.849	1.017	1.038			0.826
	Scotland ...					0.901	1.373	1.164	1.031	
	England and Wales:									
	London†		0.989							
	County boroughs	0.780	0.796	0.796	0.882	1.090				
Persons per acre, 1931	Urban districts ...	0.664	0.776	0.746	0.827	0.990				
	Rural districts ...	0.672	0.723	0.732	0.798	0.945				
	Great Britain:									
	Excluding London†	0.638	1.022	0.641	1.588	0.697	0.626	0.192	0.070	
	England and Wales:									
	Including London†	0.638	1.477	0.641	1.588	0.751	0.369			1.070
	Scotland ...					0.094	0.697	0.192	0.070	

\* Where a county lies partly in one zone and partly in another, the county aggregates have been allotted to the zone containing the major fraction of the county area.

† In this table, and throughout this paper, "London" includes, together with the Administrative County, the two adjacent County Boroughs of West Ham and East Ham.

The mean densities for England and Wales, including London, and for Scotland, are also shown separately and are depicted in Figure 1. The inclusion of London in the zone 51-52° naturally produces irregularities in the progression for

MEAN DENSITY OF PERSONS PER ACRE &amp; PER ROOM IN ZONES OF LATITUDE, 1931.

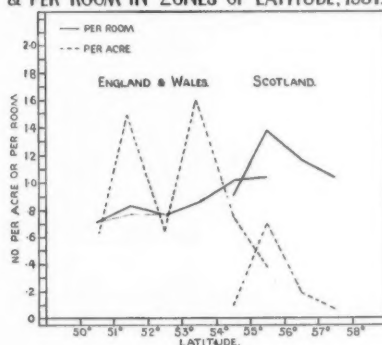


FIG. 1

both density measures, and the effect of omitting London is shown in Figure 1 by the fine dotted line for density per room.

In Table III the mean annual death-rates in 1930-32 for children under 5, expressed as percentages of the rate for all England and Wales, are shown for each zone in Great Britain, London being omitted, and for comparison the density

rates per room and per acre are also shown as percentages of the rates for the whole country. It is clear that the behaviour of the mortality rate as we pass north bears a much closer resemblance to the trend of average density per room than to the trend of density per acre. There is, in fact, a remarkable similarity between the first two, the mortality index rising from 82 at 50-51° to 144 at 55-56° and then falling, whilst the room density index rises from 86 at 50-51° to 160 at 55-56° and then falls.

TABLE III.—DENSITY AND CHILD MORTALITY RATES IN ZONES OF LATITUDE PER CENT. OF CORRESPONDING RATES IN ALL ENGLAND AND WALES.

		50°.	51°.	52°.	53°.	54°.	55°.	56°.	57°.
Great Britain excluding London	Mortality 1930-32 at 0.5 years	82	80	91	116	133	144	121	116
	Mean density per room ...	86	93	92	103	123	160	141	125
	Mean density per acre ...	51	54	65	142	64	57	18	7

In Table IV the mortality rates of children and persons over 65 are shown for the three zones—51°, 52°, and 53°—separately, when the areas in these zones are classified according to their mean density per room, and the corresponding rates are given for all England and Wales. It is seen that the relative increase of mortality as the rate of crowding increases is almost as great within each zone as it is for the whole country taken together.

TABLE IV.—MORTALITY RATES PER 10,000 IN 1930-32 IN THREE ZONES OF LATITUDE ACCORDING TO DENSITY PER ROOM.

Latitude	Age	Density of persons per room				Ratio of rate at highest density to rate at lowest
		0.55-0.69	0.70-0.84	0.85-0.99	1.00-1.14	
51° (except London)	0-1	449	592	733		
	1-5	37	48	84		
	5-15	13	15	19		
	65-	661	683	787		
52°	0-1	592	602	689	811	1.52
	1-5	46	56	80	108	2.35
	5-15	16	16	19	19	1.19
	65-	711	691	767	807	1.14
53°	0-1	645	640	776	872	1.35
	1-5	53	68	99	104	1.96
	5-15	17	18	22	23	1.35
	65-	754	765	810	854	1.13
England and Wales	0-1	505	566	735	757	1.50
	1-5	43	57	90	99	2.28
	5-15	15	16	21	21	1.40
	65-	694	707	787	789	1.14

These figures suggest the possibility that the well-known north to south gradation of mortality rates, which still persists when rural areas, small towns or large towns are dealt with separately, may arise from the gradation of overcrowding within the house and all which that implies or carries with it in social well-being, and that the climatic differences between the various latitude zones may in reality have little effect on mortality. In Figure 2 the average number of persons per room is shown for the three classes of area separately within each zone of latitude in England and Wales, the rates being given in Table II. The mean density of occupation at a given latitude is only very slightly greater for the small towns than for the rural districts, and even for the county boroughs it is only greater by about 10 or 15%.

In the same diagram the densities per room are shown for groups of areas of defined mean density per acre, and it is evident that, with such a grouping of all classes of area together, density of occupation does not appreciably increase until the density per acre exceeds 30, which is a density only found in the larger towns. The coefficient of correlation obtained when the county aggregates and county boroughs of England and Wales, without London, are distributed according

to both measures of mean density is  $r = 0.368$ , showing a lower degree of association between the two measures than might have been anticipated.

These considerations make it clear, at least, that the relations of mortality with latitude, and to a slighter degree with urbanization, are so bound up with the wide differences in the degrees of crowding of the populations within their houses that some attempt needs to be made to disentangle the three factors and determine which has the most important association with mortality. Before proceeding to that problem a few words must be said about the emergence of the idea that density of occupation of rooms or houses has an important association with the risk of dying.

#### MORTALITY AND DENSITY OF OCCUPATION OF HOUSES.

Although Farr had no statistical data of the density of occupation of houses, there is a sentence in his letter to the Registrar-General in the fifth report [4*b*], which shows that he was alive to the fact that in rural districts overcrowding within the four walls of the house might be as bad as in urban areas, for he wrote—

“ . . . the country is exposed as well as the town population to the influence of the deleterious gases in the close chambers of small cottages.”

MEAN CROWDING PER ROOM ACCORDING TO URBANIZATION AND LATITUDE, 1931.

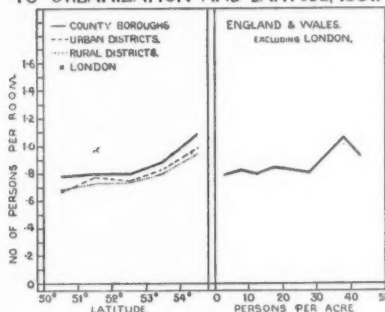


FIG. 2

In the same letter occurs a remarkable passage [4*c*] which makes one wonder whether the problems we have to solve to-day are really as different from those of ninety years ago as we like to think.

“The mortality of crowded rooms,” wrote Farr, “if carefully investigated, would no doubt be found to be in a certain inverse relation to the space, a death marking every degree of concentration of the expired atmosphere. The families of many artisans who get good wages lodge in a single small room, the rent of which is equal to that of a cottage in the country. This is a miscalculation on their part; on coming from the country they get in town higher wages, and could afford to pay for more expensive lodgings, but finding they can live in one room, do so . . . they are only reminded of the want of room and pure air by a slight present uneasiness and discomfort. As they do not trace to their causes the deaths of their children, and disabling, dangerous attacks of sickness, they are led to look upon these events as inevitable.”

The next reference to overcrowding as a factor affecting mortality which I have noticed in the Registrar-General's Reports, though my search has not been exhaustive, is in the supplement to the Sixty-fifth Report [7], relating to the decade 1891-1900, in which Dr. Tatham referred to data furnished to the Committee on Physical Deterioration by Sir Shirley Murphy, from which it appeared that in

London districts with less than 10% of the population living in overcrowded tenements the infant death-rate averaged 142 per 1,000 births, and as the proportion overcrowded increased the infant mortality also rose, attaining 223 per 1,000 when the highest degrees of crowding were reached.

More than thirty years before that, in 1869, Dr. Gairdner, Medical Officer of Health of Glasgow, had recorded his view [8] that the high death-rates in Glasgow and Greenock were mainly due to overcrowding, squalor and physical degradation which were in their turn the "direct results of permitting generation after generation to be brought up in houses of the worst construction, in which morality, decency and cleanliness are alike impossible." As a result, in the decade 1871-80, deaths in Glasgow were analysed by division of the city into twenty-four districts in which the average density of persons per room was found to range from 1.25 to 2.95, and it was ascertained that the crude death-rate, infant mortality rate and death-rates from phthisis and acute lung diseases increased as the mean density per room increased. This was followed by special studies at the periods around the 1901, 1911 and 1921 censuses in Glasgow on the relation between the number of apartments in houses and the death-rates to which the occupants were subject, and the results of those studies were given to this Society in two papers by Dr. A. K. Chalmers in 1912-13 and 1925-26 [9].

These and other researches to which time will not allow me to refer have established the fact that *within a given town* the risk of dying at any age, and particularly in early childhood, is greater to occupants of the more crowded houses than to occupants of the less crowded, but this has been variously attributed to the direct effects of the crowding, to the unfavourable industrial conditions supposed to be associated with greater crowding, to the poverty of which it is often a symptom, or to the gravitation of the less fit into unsatisfactory conditions of housing either by choice or economic compulsion.

With all this uncertainty as to which is cause and which is effect, it is not surprising that the advantages predicted from housing improvement *per se* have ranged from the most optimistic to the most pessimistic. Even in 1841 there were pessimists, for Farr wrote in the Fifth Report of the Registrar-General [4d] :—

"... The objection to these measures is that 'you take down the dwellings of the poor, build houses in their places for which the middle classes only can pay, and thus by diminishing the amount of cheap house accommodation increase the rents and aggravate the evil which you attempt to cure.' ..."

#### MORTALITY IN 1930-32 ACCORDING TO LATITUDE, DENSITY PER ROOM AND PER ACRE.

The method used in this analysis has been to enter first on a separate card for each county aggregate of rural districts, each county aggregate of urban districts, each county borough and Metropolitan borough of England and Wales, the total births in 1930-32, the total deaths at ages under 1, 1-5, 5-15, and ages 65 and over, the total deaths of females at ages 15-25, 25-45 and 45-65, the deaths from certain selected causes at certain ages, the total notified cases of certain diseases, and the mean populations in the triennium at the required ages. The cards were then sorted according to the three variables, latitude<sup>1</sup> and the two measures of density at 1931 census, and the deaths and populations of all the areas falling into a given cell formed by the three-dimensional scale were totalled, giving the mean annual mortality rate for areas in the specified zone and having the specified average conditions of density per acre and per room. Women were taken at ages 15-65 in preference to men as being less influenced by the occupation factor and more affected by overcrowding in the home.

The first problem was to determine how the change in death-rates on passing northwards was affected by correcting for both the density factors. This was done by dividing up the population in a given zone of latitude according to the twofold

<sup>1</sup> See note below Table II.

scale of density, applying to each part of it the death-rate in all England and Wales for the corresponding density values, thus finding the expected deaths in the zone if the populations within it living at different average densities per acre and per room were subject to the mortality experienced by the aggregate of all the populations in

**MORTALITY IN ZONES OF LATITUDE, 1930-32.**  
 ---- RELATIVE TO ENGLAND & WALES (CRUDE)  
 — CORRECTED FOR DENSITY & CROWDING.

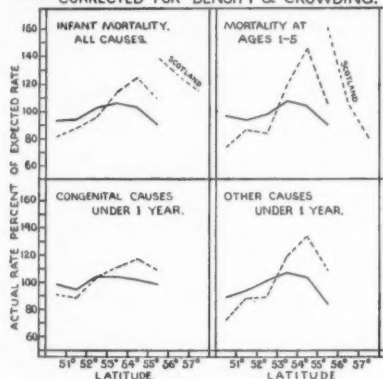


FIG. 3

**CHILD MORTALITY & PUERPERAL FEVER IN ZONES OF LATITUDE.**  
 ---- CRUDE RATIO. — CORRECTED.

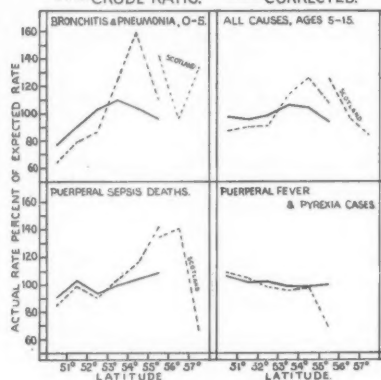


FIG. 4

**MORTALITY IN ZONES OF LATITUDE.**  
 ---- CRUDE RATIO. — CORRECTED.

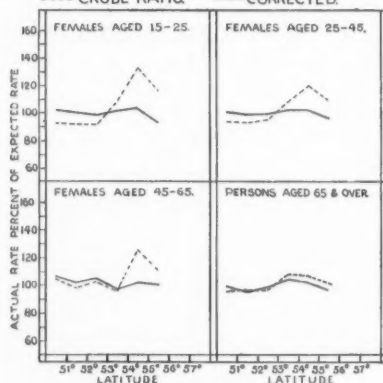


FIG. 5

**MORTALITY OF YOUNG WOMEN IN ZONES OF LATITUDE.**  
 ---- CRUDE RATIO. — CORRECTED.

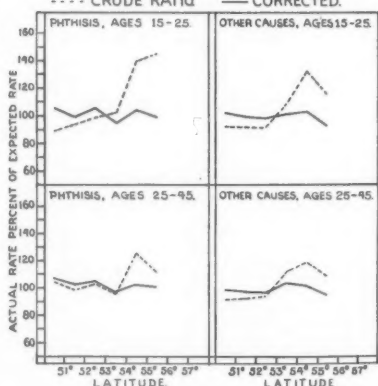


FIG. 6

England and Wales living at those average densities. The total of registered deaths in the zone was then expressed as a percentage of this total of expected deaths.<sup>1</sup>

The results are shown in Table V and in Figures 3 to 6, and the conclusions to be drawn are as follows:—

<sup>1</sup> It has been shown repeatedly that mortality increases with urbanization within each region of the country, and analysis of separate zones according to room density, of which a sample is given in Table IV, proves that it also increases with crowding within each zone to much the same extent as in the country as a whole. This method of correction is therefore justifiable, though it leads to some over-correction at the north end of the curves. It should be noted that a horizontal corrected curve of mortality on latitude does not prove that latitude is not a factor involved, but only that the density factors alone would suffice to explain the change of mortality with latitude.

TABLE V.—MORTALITY IN 1930-32 ACCORDING TO LATITUDE.

Sex	Age	Cause	Latitude zone	Mortality rate per cent. of that in all England and Wales						Mortality per cent. of that expected from distribution of populations according to density per acre and per room					
				England and Wales			Scotland §			England and Wales					
				50°.	52°.	53°.	53°.	54°.	57°.	50°.	51°.	52°.	53°.	54°.	55°.
Persons	0-1*	All causes	...	80	88	96	114	125	103	138	126	115	93	94	102
	1-5	"	...	...	...	...	...	...	...	...	...	...	96	93	106
	5-15	"	...	73	86	93	120	146	105	161	106	80	98	108	102
	15-25	"	...	87	90	91	113	126	106	126	97	83	98	95	98
	25-45	"	...	91	93	95	106	135	128	...	...	...	104	99	101
Persons	45-65	"	...	94	93	95	108	120	110	...	...	...	100	98	99
	65 and up	"	...	94	93	94	111	112	106	...	...	...	101	97	97
	0-1	Congenital causes†	...	95	96	96	108	107	102	132	103	103	99	95	98
	0-1	Other causes	...	91	88	102	110	115	109	...	...	...	98	95	102
	0-5	Bronchitis, pneumonia	...	70	88	90	118	134	108	142	95	134	88	94	103
Females	0-5	Whooping-cough	...	64	78	85	125	161	109	179	212	105	77	91	101
	15-25	Phthisis	...	77	79	100	118	143	112	315	104	79	98	89	118
	15-25	Other causes	...	89	94	98	102	139	145	104	79	102	105	99	105
	25-45	Phthisis	...	92	92	92	109	132	115	...	...	...	102	99	98
	25-45	Other causes	...	105	98	102	95	125	110	91	100	89	107	102	105
Persons	+	Puerperal sepsis	...	91	92	93	112	119	109	...	...	...	98	97	97
	+	Puerperal fever and pyrexia cases	...	84	99	90	104	116	142	134	140	69	90	103	93
	+	Rates based on births.	...	107	105	98	95	98	69	...	...	...	105	101	102
	+	Notified cases of "fever" and "pyrexia" combined.	...	...	...	...	...	...	...	...	...	...	...	...	...
	+	Notified cases of "fever" and "pyrexia" combined.	...	...	...	...	...	...	...	...	...	...	...	...	...

\* Rates based on births.  
† Notified cases of "fever" and "pyrexia" combined.  
‡ Nos. 157-161 in International List of causes (4th revision).  
§ Scottish rates relate to 1931 only; some of the rates for 56°, and 57°, are based on small numbers and are therefore subject to considerable chance errors; the rates for the small portion of Scotland in zone 54° have been omitted entirely for the same reason.

(i) Infant mortality, uncorrected, increased from 80% of the national rate in the southernmost zone to 125% at 54°, the Durham zone, and 135 at 55°, combining the Scottish zone with a small portion of Northumberland at this level. It then declined to 115% in North Scotland. The densities per room in some of the Scottish industrial counties being larger than any values for English units of area, it was not possible to calculate the expected deaths in that zone unless by some process of extrapolation of the rates in Table VIII, but it was found that by any such process of correction the values 135, 126 for 55°- and 56°- would be reduced below 100. The range of corrected ratios was, therefore, from 93-94 in the South to 102-106 in the industrial North and the effect of latitude in itself on the infant mortality rate cannot be very important (Figure 3).

(ii) Mortality, uncorrected, of children aged 1-5, increased from 73% of the national rate in the southernmost zone to 155 at 55°- combining the Scottish zone with the small portion of England, but the effect of correction for density and crowding was to reduce the northward increase to something quite moderate, the rates ranging from 93 at 51°- to 108% at 53°-. The high rate at 55°- was again reduced below 100 if the expected deaths at the high densities per room were estimated by a process of extrapolation, as mentioned above for infant mortality (Figure 3).

(iii) Mortality of children aged 5-15 also showed only slight variation with latitude after correction, the range being from 93 to 106% of the expected rates.

(iv) Mortality of women aged 15-25, 25-45, and 45-65, and of persons over 65, showed no appreciable relation to latitude after correction.

(v) Infant mortality from congenital causes varied very slightly with latitude, not diverging for any zone by more than 5% from the expected value. Infant mortality from all other causes increased from 88% of the expected rate in the southernmost zone to 107% at 53°-, the Lancashire and Yorkshire industrial area, and then declined to 84% in the northernmost zone of England (Figure 3).

(vi) Mortality of children under 5 from bronchitis and pneumonia combined increased from 77% of that expected in the southernmost zone to 110 at 53°-, but then declined to 96% in the northernmost zone of England. For whooping-cough the ratio was highest in the central zones, 52°- and 53°-.

(vii) Mortality of young women aged 15-25 and 25-45 from phthisis showed, after correction, no tendency to increase northwards, nor did that of young women from causes other than phthisis (Figure 6).

(viii) Mortality from puerperal sepsis, uncorrected, increased from 84% of the national rate in the southernmost zone to about 140 at 55°- and 56°-. After correction for density and crowding the rate still tended to increase slightly from south to north, the high rate at 51°- being due to London, which forms an exception. Notified incidence of puerperal fever and pyrexia, uncorrected, showed the reverse tendency to decline from south to north, but this became unimportant after correction (Figure 4).

The broad conclusion is that it is not necessary to suppose that at ages over 5 mortality from all causes combined is appreciably affected by climatic differences dependent upon latitude, within the limits of England and Wales, and probably of Great Britain. The same is true of phthisis in young women and infant mortality from congenital causes. The mortality of young children under 5 from respiratory disease shows an increase in passing from the south coast to the industrial north of England amounting to 42% even after allowance has been made for the effects of the increasing density and crowding per room, but there is a decline on passing further north. The similar, though slighter, changes in infant mortality from causes not congenital may be presumed to be also due to the respiratory diseases which form the bulk of these deaths. Whooping-cough mortality behaved similarly.

It is rather a surprising feature of our climatic conditions that the average number of hours of sunshine recorded in the year at stations in the eastern half of the United Kingdom decreases as we pass northwards from the south coast until latitude zone 53° is reached, but after that the average gradually increases again. This was true at least for the mean annual sunshine in 1930-32, as I have shown in Table VI. The averages have been obtained by sorting 173 recording stations, for which all three years records were available into the latitude zones, and also dividing England and Wales into east and west halves along the line of longitude 2° W., and Scotland into east and west halves along the line of longitude 4° W., totalling the hours of sunshine in the three years as given in the returns of the Meteorological Office, and dividing by three times the number of stations included.

TABLE VI.—MEAN ANNUAL HOURS OF SUNSHINE IN 1930-32 AT METEOROLOGICAL STATIONS IN ZONES OF LATITUDE.

	40°.	50°.	51°.	52°.	53°.	54°.	55°.	56°.	57°.	58°-61°
West of long. 2° W. (Scotland 4° W.)	1,741	1,522	1,395	1,277	1,263	1,190	1,139	1,131	1,235	1,217
East of long. 2° W. (Scotland 4° W.)		1,625	1,451	1,347	1,217	1,281	1,285	1,324	1,256	
All stations ...		1,578	1,438	1,332	1,242	1,241	1,195	1,257	1,249	
County boroughs only		1,562	1,373	1,264	1,162	1,229				
Other stations ...		1,576	1,444	1,347	1,298	1,246				

HOURS OF SUNSHINE RECORDED IN 1930-32 IN ZONES OF LATITUDE.

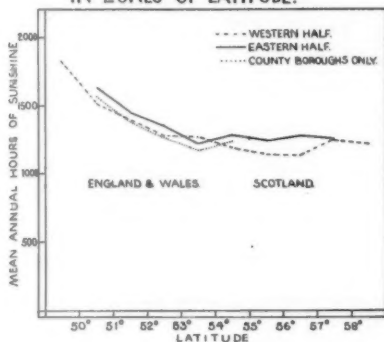


FIG. 7

The result is depicted in Figure 7. The curve for the eastern half is an inversion of the corrected mortality curve for bronchitis and pneumonia at ages under 5 in the same years (Figure 4). For the western half the decline continues to 56°, but in the 54° zone the great bulk of the population is in the eastern part. In some of the divisions the number of stations is small, and they may have exceptional situations. It would also be better to make use of more years than three, but the curves show clearly the advantage which is claimed for the east, except at 53°, where we see, I think, the effect on sunshine records of the smoke blanket, which, as any motorist who travels frequently up the Great North Road knows, blows over this part of England from the industrial towns to the west. When the county boroughs are averaged separately they show a mean deficiency from other stations of fourteen hours at 50°, seventy-one at 51°, eighty-three at 52°, one hundred and thirty-six at 53°, and seventeen at 54°, which gives, no doubt, a rough measure of the smoke effect.

I have made this digression about sunshine because, although I admit that, strictly speaking, it proves nothing, I believe myself that Tables V and VI, in conjunction, are just a statistical demonstration of a statement by Professor Haven Emerson of Columbia in a recent paper [10] on "Sunlight and Health," from which I take the liberty of condensing an extract:—

"Insufficient sunshine . . . is responsible for one clearly defined clinical entity, rickets. . . . Nothing is plainer in the morbidity and mortality experience of our

northern cities than that the presence of rickets contributes heavily to sickness and death from bronchitis and pneumonia in young children, to lowered resistance to measles, whooping cough and tuberculosis, and more remotely to maternal deaths from difficult instrumental or operative deliveries."

Apart from these special effects of diminished sunshine on children, I am not convinced that there is any real evidence that the differences in average mortality experience between different parts of Great Britain have anything to do with climate.

The next problem was to determine whether now, with improved sanitation of towns, the crowding of people within their houses has assumed a greater importance in its association with mortality than the crowding of their houses together. In Table VII London (including West and East Ham), and England and Wales without London, have been divided up as explained above on a scale of mean density per acre and the death-rates expressed as percentages of the corresponding rates for all England and Wales. The mortality in each density group of England and Wales without London has then been expressed as a percentage of the expected mortality if the unit areas forming the group in question were distributed on the scale of mean density per

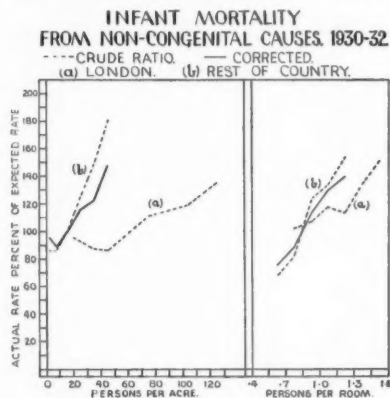


FIG. 8

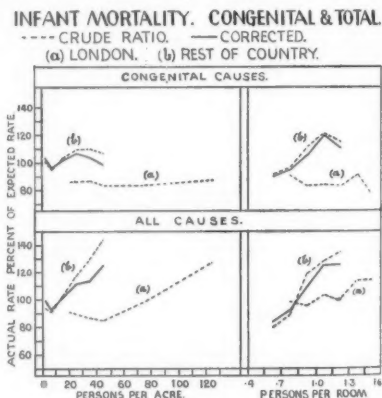


FIG. 9

room and their populations subjected to the combined rate for all areas of England and Wales having the appropriate density per room. In other words, the rate for each group is corrected for the effect of differing distribution according to mean destiny per room of the populations which combine to form the group.

In Table VIII mortality has been classified in precisely the converse manner on a scale of mean density of persons per room in the area, correcting for differences in urbanization as measured by density per acre.

The results set out on Tables VII and VIII are depicted in Figures 8 to 20. These diagrams have been so drawn that the standard deviations of persons per room and per acre for the unit areas of England and Wales, excluding London, occupy approximately the same horizontal length, and hence the relative importance of the two factors in relation to mortality is graphically indicated by the relative slopes of the two corrected curves, which are represented by the unbroken lines in Figures 8 to 20.

The conclusions to be drawn seem to be as follows:—

(1) London mortality is uniformly lower than that of the rest of England and Wales when districts of the same density per acre are compared, and this is also

TABLE VII.—MORTALITY IN 1930-32 ACCORDING TO MEAN DENSITY PER ACRE.

Sex	Age	Cause	Persons per acre {	Mortality rate per cent. of that in all England and Wales										Mortality per cent. of that expected from the distribution of populations according to density per room									
				London†										England and Wales except London‡									
				10.	20.	30.	40.	50.	100.	0.	5.	10.	20.	30.	40.	50.	0.	5.	10.	20.	30.	40.	50.
Persons	0-1*	All causes	...	91	87	85	98	127	93	90	101	117	129	144	99	92	101	111	114	125			
"	"	"	...	92	71	91	116	140	85	85	98	138	164	146	97	89	98	121	131	116			
"	5-15	"	...	82	70	84	111	94	109	95	95	99	115	133	123	100	97	98	110	109			
Females	15-25	"	...	108	117	80	90	96	97	99	91	94	116	129	134	105	94	111	113	117			
"	25-45	"	...	89	83	86	98	95	98	100	93	97	112	121	128	103	95	97	107	111			
"	45-65	"	...	91	98	85	95	99	110	97	93	100	113	115	131	101	95	100	109	105			
Persons	65 and up	"	...	104	96	91	96	103	108	104	96	91	96	103	108	100	97	101	104	103			
"	0-1	Congenital causes §	...	85	86	83	83	87	101	95	102	109	110	106	103	96	101	107	104	99			
"	0-1	Other causes ...	...	96	87	86	111	135	86	86	100	124	148	180	96	89	101	116	122	147			
"	0-5	Bronchitis, pneumonia	...	87	69	73	108	118	83	83	100	139	170	184	97	87	100	126	133	154			
"	0-5	Whooping-cough	...	65	78	80	111	127	85	80	101	132	167	161	94	83	101	131	152	129			
Females	15-25	Pthiasis	...	141	110	86	98	104	97	94	91	95	125	135	156	101	95	94	119	116			
"	15-25	Other causes	...	84	123	76	84	90	97	103	92	94	109	125	117	110	94	104	111	103			
"	25-45	Pthiasis	...	125	68	91	114	97	104	94	92	98	125	131	133	97	94	99	121	120			
"	25-45	Other causes	...	78	88	84	94	94	96	102	94	97	108	118	127	105	95	96	103	108			
"	"	Puerperal sepsis	...	131	127	119	145	101	89	100	92	101	104	94	164	103	93	100	99	86			
"	"	Puerperal fever and pyrexia cases	...	...	...	...	143	125	80	94	119	106	110	87	83	94	118	105	106	81			

\* Rates based on births.

† Notified cases of "fever" and "pyrexia" combined; these rates refer to England and Wales including London.

‡ See note below Table II.

§ Nos. 157-161 in International List (4th revision).

TABLE VIII.—MORTALITY IN 1930-32 ACCORDING TO MEAN DENSITY PER ROOM.

Sex	Age	Cause	Persons per room	Mortality rate per cent. of that in all England and Wales										Mortality per cent. of that expected from the distribution of populations according to density per acre									
				England and Wales except London†										England and Wales except London									
				London‡																			
				0.70.	0.85.	1.00.	1.15.	1.30.	1.45.	0.55.	0.70.	0.85.	1.00.	1.15.	0.55.	0.70.	0.85.	1.00.	1.15.				
Persons	0-1*	All causes	..	96	95	101	98	113	114	79	88	118	127	135	83	92	110	125	125				
	"	"	..	93	103	117	133	147	174	60	79	129	147	163	68	87	121	142	144				
	5-15	"	..	93	91	97	100	107	119	82	90	117	121	142	85	92	113	117	132				
	Females	15-25	..	75	101	95	120	94	116	84	90	118	133	151	85	91	114	133	139				
	"	25-45	..	86	93	96	106	103	108	91	93	114	119	133	92	94	111	119	125				
Persons	45-65	"	..	50	96	104	110	120	116	92	93	114	115	119	94	95	112	116	115				
	65 and up	"	..	95	100	105	112	113	99	95	97	109	110	108	96	98	108	108	105				
	0-1	Congenital causes §	..	102	107	118	114	134	151	68	81	125	136	154	76	88	113	133	139				
	"	Other causes	..	86	95	109	123	117	134	55	76	135	164	192	62	83	122	155	159				
	"	Bronchitis, pneumonia	..	105	92	120	117	117	117	68	84	128	123	145	76	92	119	118	126				
Females	0-5	Whooping-cough	..	75	112	108	122	88	124	82	87	118	140	152	85	91	112	139	138				
	15-25	Phthisis...	..	76	99	86	109	109	104	102	90	127	150	85	91	115	129	140					
	"	Other causes	..	82	101	101	125	104	102	99	92	108	118	148	102	95	103	117	136				
	Females	25-45	..	88	91	94	100	103	110	89	94	115	120	128	89	94	113	120	122				
	"	25-45	Other causes	..	126	112	86	109	80	84	91	114	114	105	92	92	112	117	103				
"	45-65	Puerperal sepsis	..																				
"	†*	Puerperal fever and pyrexia cases	..																				

\* See note below Table II.

† Nos. 157-161 in International List (4th revision).

\* Rates based on births.

† See note below Table VII.

true, though the advantage is not so great, when districts of the same density per room are compared. The only exceptions are at a few age-groups in the least densely populated or housed parts of London. Table IX shows the percentage ratios of London mortality to that in the rest of England and Wales at various densities and ages. At ages under 5 the advantage of London must derive partly from its southern situation with consequent greater amount of annual sunshine, as indicated by the remarkably low comparative rates in Table VIII for bronchitis and pneumonia at the higher densities.

TABLE IX.—LONDON † RATES AS PERCENTAGE OF THOSE IN THE REST OF ENGLAND AND WALES AT THE SAME DENSITIES.

Sex	Age	Cause	Density per acre				Density per room			
			10.	20.	30.	40-50	0.70.	0.85.	1.00.	1.15-1.30
Persons	0-1	All causes	86		67	59	109	80	79	73
"	1-5	"	82		43	62	118	80	80	82
"	5-15	"	83	61	63	90	104	77	80	70
Females	15-25	"	115	101	62	67	84	86	72	79
"	25-45	"	92	74	71	77	93	82	80	80
"	45-65	"	91	86	74	73	96	84	90	93
Persons	65 and up	"	103	90	83	81	99	92	96	104
	0-5	Bronchitis and pneumonia	86	81	36	39	113	71	67	64

† See note below Table II.

MORTALITY AT AGES 1-5, ALL CAUSES.

--- CRUDE RATIO. — CORRECTED.  
(a) LONDON. (b) REST OF COUNTRY.

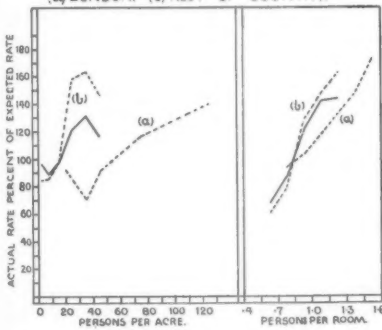


FIG. 10

MORTALITY AT AGES UNDER 5.

R-BRONCHITIS & PNEUMONIA. W-WHOOPING-COUGH.  
--- CRUDE RATIO, LONDON. — CORRECTED, REST OF COUNTRY

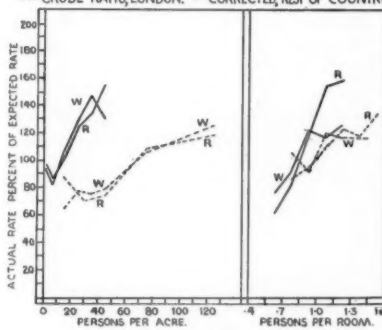


FIG. 11

At ages over 5, although the climatic factor would seem to be unimportant, yet for some reason London has in general at ages 5-45 an advantage amounting to one-fifth to one-third over other parts of the country of the same densities per acre or per room. At ages over 45 the advantage becomes less. It is because of this, to me, inexplicable advantage of London, that I have dealt with it separately throughout. Is the greater triumph over environment by people living in the Metropolis due to selective migration of the healthiest young adults into London, to a greater immunity against certain diseases afforded by living in the middle of a vast herd, to better protection from the rigours of winter afforded by the amenities of London, to better facilities for medical treatment, to more advanced public health, or to all of these? I do not know, but it is a question which, it seems to me, our statistical records ought to be able to answer, if only one had the necessary clerical assistance to analyse them exhaustively, cause by cause, age by age, occupation by occupation, and social class by social class.

(ii) A study of the London curves, which are simple percentage ratios to the death-rates in the whole country, and are denoted by (a) in Figures 8-19, shows that

in the Metropolitan Boroughs infant mortality from congenital causes has no association with either measure of density, but from other causes the rate shows an increase at densities over 50 per acre and rises with increasing density per room from 102 at 0.77 per room to 151 at 1.52. At ages 1-5 there is again no evident effect until density per acre exceeds 50, but the rate increases steadily from 93 at 0.77 per room to 174 at 1.52. Mortality from bronchitis and pneumonia at ages under 5 is similarly affected, but the whooping-cough rate is only slightly affected by density of occupation. At the school ages there is little relation with density per acre, but the rate rises with crowding from 91 at 0.92 per room to 119 at 1.52, a range only about

#### MORTALITY OF CHILDREN AGED 5-15.

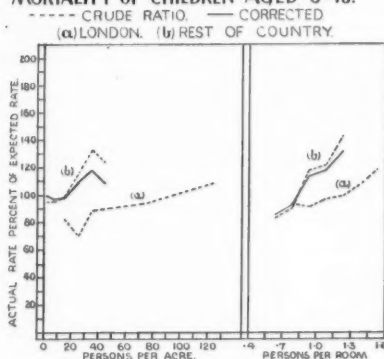


FIG. 12

#### MORTALITY OF WOMEN AGED 15-25, PHTHISIS & OTHER CAUSES.

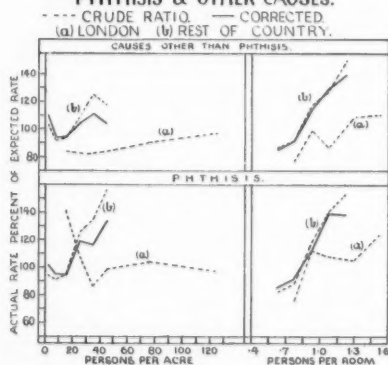


FIG. 14

#### MORTALITY OF WOMEN AGED 15-25.

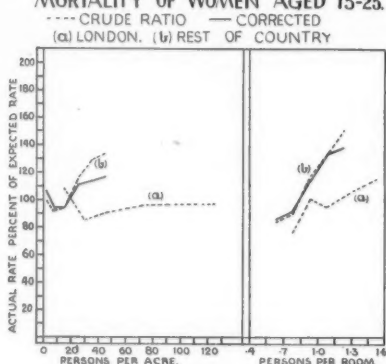


FIG. 13

#### MORTALITY OF WOMEN AGED 25-45.

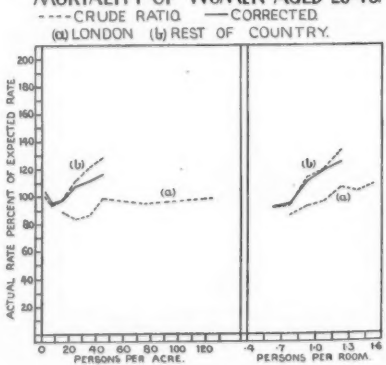


FIG. 15

one-third as great as at the pre-school ages. For young women aged 15-25 and 25-45 the phthisis rates are actually highest at low densities per acre, but increase with crowding up to 1.22 per room, though not beyond; for other causes the rates show little change with density per acre, but increase with crowding from 76 to 110 at ages 15-25 and from 88 to 110 at ages 25-45. For women aged 45-65 there are slight increases with both measures of density, and for persons over 65 the effects have become scarcely appreciable. Puerperal sepsis shows a lower rate at densities over 50 per acre, and declines with increasing crowding from 126 at 0.77 per room to 54 at 1.52. In this connection it may be noted that Russell [11] found no correlation

between puerperal fever and overcrowding in London in 1911-14, but in Glasgow 1903-13 positive correlations of the order 0.5 were obtained.

(iii) Mortality in England and Wales excluding London is denoted by (b) in Figures 8-19, and the corrected rates reveal the association with each measure of density when the other measure has been rendered constant. In Table VI it is seen that at each age and for each cause of mortality dealt with the corrected ratios at 5-10 persons per acre were, if anything, lower than at 0.5 per acre, so the effect of increasing density was not felt below 10 per acre. The corrected ratio for infant mortality from congenital causes shows no association with density per acre, but rises with crowding from 90 at 0.62 per room to 117 at 1.07; for other causes the corrected ratio shows a strong association with both density measures, increasing from 89 to 147 with density per acre, and from 76 to 139 with crowding per room.<sup>1</sup> At ages 1-5 the ratio increases from 89 at 5-10 per acre to 131 at 30-40, and from 68 at 0.62 per room to 144 at 1.22, indicating that crowding within houses is the more important factor at pre-school ages. This also applies to

#### MORTALITY OF WOMEN AGED 25-45, PHTHISIS & OTHER CAUSES.

--- CRUDE RATIO. — CORRECTED.  
(a) LONDON. (b) REST OF COUNTRY.

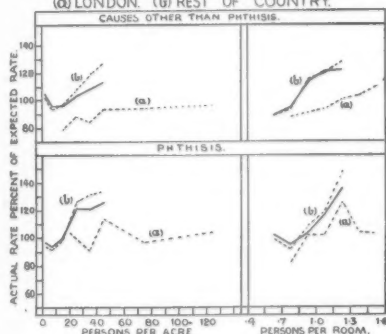


FIG. 16

#### MORTALITY OF WOMEN AGED 45-65.

--- CRUDE RATIO. — CORRECTED.  
(a) LONDON. (b) REST OF COUNTRY.

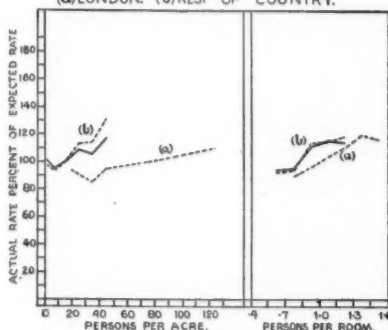


FIG. 17

respiratory diseases at ages under 5, but for whooping-cough density per room is not so important. At the school ages densities over 30 per acre have slightly higher rates, but the range is only from 97 to 119, whereas with crowding the rate rises steadily from 85 to 132. For young women aged 15-25 and 25-45 phthisis is affected by densities over 20 per acre, and to a rather greater extent by crowding per room<sup>2</sup>; mortality from other causes is not appreciably affected by density per acre, but rises steadily with crowding from 85 to 140 at ages 15-25 and from 89 to 122 at 25-45. For women aged 45-65 the effects of density by either measure are slight, and for persons over 65 become almost inappreciable. Puerperal sepsis mortality does not increase with density per acre except at 40-50 per acre, but there is a general upward trend with crowding which contrasts strangely with the similar curve for London. Notification rates of puerperal fever and pyrexia combined, based on the number of live births, and computed for the whole country including London, show a positive association with density per acre, but a negative one with crowding per room, as depicted in Figure 20.

<sup>1</sup> P. L. McKinlay [12] found a negative correlation of  $-0.971$  between post-natal infant mortality in 1921-23 and rooms per person in 1921 in the county boroughs,  $-0.775$  in the urban districts and  $-0.745$  in the rural districts.

<sup>2</sup> A. Newsholme [18] in his presidential address to this Society in 1907 remarked: "It is common ground that, far more than most diseases, phthisis is affected by privation and overcrowding."

In Figure 21 the relative effects of density per acre at constant density per room at the successive ages are shown in the portion A, and it is readily seen that at 0-5, 5-10 and 10-20 per acre there is no important association, but at higher densities mortality rises by 10 to 20% at ages between 5 and 65, and by rather more in young children and less in old people. In portion B the effect of density per room at constant density per acre is seen to be that mortality increases by steps in passing from 0.55 to 1.30 per room; the range is greatest at ages 1-5,<sup>1</sup> diminishes quickly at the school ages, expands again for young adult females and then steadily diminishes with advancing age. Up to middle life the importance of crowding per room as a factor in mortality would appear to be now almost double that of density per acre.

#### MORTALITY AT AGES 65 & OVER.

--- CRUDE RATIO. — CORRECTED.  
(a) LONDON. (b) REST OF COUNTRY.

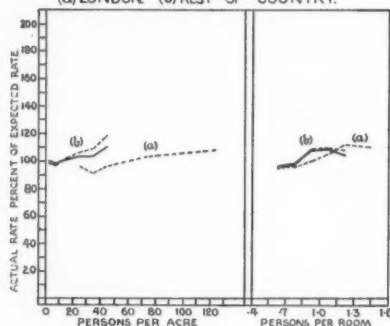


FIG. 18

#### NOTIFIED INCIDENCE OF PUERPERAL FEVER AND PYREXIA.

--- CRUDE RATIO. — CORRECTED.

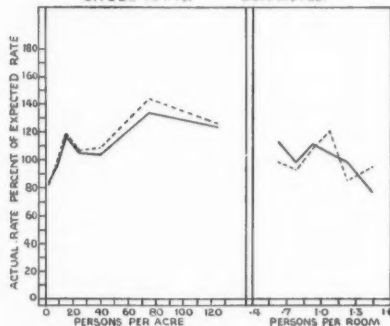


FIG. 20

#### MORTALITY FROM PUERPERAL SEPSIS.

--- CRUDE RATIO. — CORRECTED.  
(a) LONDON. (b) REST OF COUNTRY.

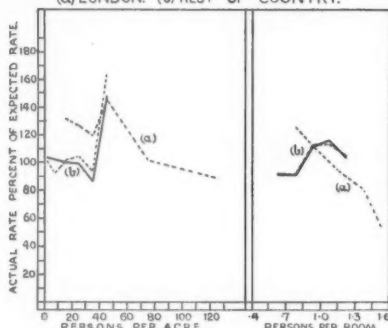


FIG. 19

#### MORTALITY AT DIFFERENT AGES ACCORDING TO — A. NUMBER OF PEOPLE PER ACRE AT CONSTANT DENSITY PER ROOM. B. NUMBER OF PEOPLE PER ROOM AT CONSTANT DENSITY PER ACRE

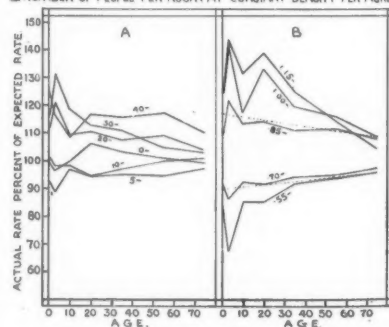


FIG. 21

This concludes my presentation of the facts. Regarding the practical inferences to be drawn from them there will doubtless be a diversity of opinion, and I would like before concluding to contribute a few personal observations bearing upon their interpretation. The question one would like to be able to answer is, to what extent does the association of mortality with density per room imply that overcrowding *per se* increases the risk of dying and shortens the expectation of life? There is undoubtedly a high correlation between the

<sup>1</sup> It may be that in districts where overcrowding is most severe the relative proportion of children in overcrowded houses, when compared with better housed areas, is greater than for adults, but if so, this would affect all ages up to 15.

mean crowding index in a district and the proportion of the population living below the poverty line, that is to say, with insufficient income to supply all the necessities of life.

In the recent volumes of the New Survey of London Life and Labour we have some data by which to test from various aspects the association in London districts between poverty, housing and mortality. By extracting from Volumes III and VI the data for the thirty-seven districts I have obtained, for example, the following coefficients of correlation:—

Mean No. of persons per room with	per cent. of population in poverty	...	...	0.848 ± 0.032
"	mean income in excess of rent	...	...	0.172 ± 0.108
"	infant mortality rate	...	...	0.359 ± 0.097
"	crude death-rate	...	...	0.274 ± 0.102
Proportion below poverty line with	infant mortality rate	...	...	0.226 ± 0.105
"	crude death-rate	...	...	0.371 ± 0.096
Proportion living over 2 per room with	per cent. of population in poverty	...	...	0.734 ± 0.051
Income in excess of rent with	infant mortality rate	...	...	-0.394 ± 0.094
"	crude death-rate	...	...	-0.447 ± 0.089
Acres of open space per 100,000 with	infant mortality rate	...	...	-0.423 ± 0.091

When the number of persons per room is made constant, the partial correlation between proportion in poverty and infant mortality rate becomes zero ( $-0.068 \pm 0.105$ ), but when the proportion in poverty is made constant the correlation of persons per room with infant mortality becomes  $0.323 \pm 0.097$ , which is significant, and when mean income in excess of rent is constant the correlation of persons per room with crude death-rate becomes  $0.399 \pm 0.102$ , also significant.

The index of mean persons per room is highly correlated with the proportion living in poverty, more highly even than the usual index of overcrowding, but it has no negative relation with the average income available for the necessities of life over and above rent. Sir Llewellyn Smith remarked on page 109 of Volume III: "The result of the arrest of housebuilding and the shortage of houses in recent years has been that many working-class families who in other respects are comparatively well off have been compelled to put up with a degree of crowding which in Charles Booth's time would have been symptomatic of poverty." Farr complained, in the passage I quoted above, that in his day many of them did the same, not from compulsion but from choice.

In spite of the complex relation between the indices of crowding and economic factors, I do not think that more than a part of the explanation of Figure 21B is to be found in economics.

Can the association summarized in Figure 21B be explained by social selection of the people who live at different densities per room, apart from their differing command over food and so forth? A graded relation of mortality with social class is found when the sections of the population not dealt with in this paper, namely, men aged 15-65, are divided into five social groups, the range of variation being greatest at ages 25-45. If we could distribute our unit areas on a scale measuring the proportion, say, of the two lowest social groups in their total populations, we might obtain curves of mortality somewhat similar to those in Figures 13, 15, 17. This would be partly due to differing occupational risks, but mainly to social selection and the differing environment involved therein. The association of mortality with social selection is believed by some to arise by gravitation of the less fit into the lower grades, and consequently the most crowded houses, owing to inability to earn good wages, but if this were of outstanding importance the divergence of the mortality curves ought, I should think, to increase as age advances, and not as in Figure 21B, diminish. In the New Survey of London it was found that illness or physical incapacity is to-day a quite unimportant cause of poverty, and therefore, it may be presumed, of overcrowding also.

I think we might mark out the utmost limits of the contribution of social selection to the dispersion in Figure 21B by drawing straight lines from the points for congenital causes of death in infants to the points for persons over 65. The relative congenital death-rate is probably a fair index of the relative mortality to be expected throughout the early part of life in the stock from which the infants come, given the same environment, and it may be argued that by age 65 environment will have done its worst and that the old-age rates will again measure selection. The range of mortality on the crowding scale is 90-117 for the congenital death-rate and 96-108 for the old-age rate, as may be seen from the right-hand portion of Table VIII. If we so regard the straight lines thus obtained (shown as broken lines in the diagram) the amount of mortality variation within these lines would not be affected by improved housing, but only the variation over and above this, which must be attributed to the environment itself. It is possible to calculate what is the improvement to be anticipated

if all the unit areas were so supplied with housing accommodation that their average of crowding was reduced to that of the best group, namely, 0.625 persons per room. I find by such a calculation that if we make in this way the utmost concession to physical selection, a saving of about 9,000 deaths of children under 5 per annum out of 60,000 might be anticipated, with a further saving of about 10,000 at later ages. If, on the other hand, we make no concession to selection and attribute the whole observed variation to the effects of the overcrowding, the annual saving expected on that basis is 15,750 deaths under 5, and 33,000 at later ages.

I have been giving somewhat free play to my statistical imagination in this concluding portion of the paper, but it is at least a safe conclusion that the effects of overcrowding are far and away most serious at the pre-school ages, and it will be here that we may look for the greatest benefits as a result of housing improvements in the future. Furthermore, if we agree, though it be only in part, with the authors of a recent remarkable paper in the *Lancet* [14], any such benefits conferred upon the children, and reflected in their reduced mortality, will not cease when childhood is over, but will continue to show themselves in lower death-rates, which mean also better health, at later ages as those children grow up.

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Professor GREENWOOD said that Dr. Stocks' exposition was clear but the mass of detail he had assembled was so great that it was necessary to read and re-read the paper before the whole discussion could be mastered. Perhaps a little fuller description of the method of obtaining the expected figures of, for instance, Table V, would have been welcome. What he (Professor Greenwood) understood Dr. Stocks to have done was to have made a table of double entry for rates of mortality of England and Wales by density per acre and per room. This, of course, involved grouping. As the expected value for a room density of  $a$  and an acre density of  $a'$  in the latitude zone of, say,  $51^\circ$ , he would, he imagined, have taken the mean value of the entries in the  $(a, a')$  square of his England and Wales table. If this was the process it must sometimes happen that the "observed" and "expected" were based upon the same or almost the same exposed to risk. The determination of "expected" values by a regression equation, using the two density measures as the independent variables, would not, he thought, really get out of the difficulty. He was always puzzled in such investigations what weights to choose.

It seemed to him that, with the exceptions he had specified, Dr. Stocks had made out a very strong case indeed for the proposition that, in Great Britain, mortality was independent of climate. In this connection he remembered noting that, for 1901-10, the rate of mortality from diseases of the respiratory system at ages 45-55 and 55-65, which in Lancashire was far above the England-and-Wales rate, was in the adjacent Cumberland and Westmorland below the England and Wales rate. The rates of mortality from bronchitis on males aged 65-75 were, England and Wales, 7.4 per 1,000, Lancashire 12.6, Cumberland and Westmorland 4.8.

## Section of Psychiatry

President—E. MAPOTHER, M.D.

[March 13, 1934]

### DISCUSSION ON CONSTITUTIONAL PSYCHOPATHY

**Dr. R. D. Gillespie:** This is a topic which, so far as psychiatric literature in this country is concerned, appears to be disproportionately neglected. A list of titles of any works on this or an allied topic shows very few references to work done here. At a time when there is an increasing realization on all hands of the need for efficiency and happiness, both on an individual and national scale, it seems opportune to bring under discussion a topic which is regarded as of sociological importance abroad and which, as those of us who are in psychiatric work are aware, furnishes many a touchy problem here also.

The immediate cause of my suggesting a discussion of this kind was a request from a body concerned with social welfare, for a definition of this group—a definition which would appeal to the legal mind. This is an unusually difficult task, but as the need for a definition may arise in a very practical way in the near future, it seems desirable to examine the data so as to gain an idea whether any such definition will ever be possible.

As a preliminary, it is worth while referring to the nomenclature which has hitherto been used. The following table is a list compiled by Partridge, of the different terms which have been used from time to time to designate the kind of case to which this discussion refers.

#### NOMENCLATURE. (PARTRIDGE.)

Constitutional inferior.	Constitutional psychopathic state.
Constitutional psychopathic inferior.	Moral imbecile.
Constitutional psychopathic personality.	Constitutional defective.
Psychopathic personality.	Defective delinquent.
Psychopath.	Emotionally unstable or inferior.
Constitutional psychopath.	Neurotic constitution (recent).
	Instinct character (recent).

Of these thirteen designations the term "moral imbecile" represents the English contribution, which, as you know, obtained recognition in the Mental Deficiency Acts, and has recently in the latest Act of 1927 been altered to "moral defective." The term was first formally proposed by J. C. Pritchard in his treatise on insanity, 1835, p. 12, which was itself a translation of Heinroth's work (quoted from Burt, "The Young Delinquent").

Subsequently, in 1888, Koch introduced the term "psychopathische Minderwertigkeit" or "psychopathic inferiority." The concept was a more detailed one than Pritchard's. Since Koch's time much has been written about the subject in the German literature, from various angles. In the American literature, according to Huddlestone and Partridge, the term "constitutional psychopathy" was first introduced by Adolf Meyer in 1906. The terms "constitutional psychopathic inferiority" and "constitutional psychopathic personality" are still both in use at Professor Meyer's clinic, the former suggesting all-round inadequacy, whereas the psychopathic personality is one that may be quite adequate in certain directions, but shows marked instability in others. Such a person may be fairly useful socially up to a point but is reduced in efficiency, and perhaps at intervals completely disabled, by some pronounced anomaly of behaviour. The term "psychopath" is, in the opinion of most, too vague and generalized to designate such a group as it is proposed to circumscribe. All terms containing the word "constitutional" are somewhat unfortunate, in view of the indefiniteness of the connotation of

"constitution" itself. It is desirable to avoid trying to illuminate *obscurum per obscurius*. Terms containing the word "defective" are to be ruled out for various reasons, one being the obvious association with defect of intelligence, and the other that it begs the question of what is defective and makes no allowance for the fact that some of the patients in question may suffer from an excess of something. The terms containing the words "moral" or "inferior" are undesirable, because of the connotation of social criticism, while the term "instinct character" can only be deplored as a misuse of two good words which when compounded in this way do not denote anything specific.

I would tentatively support the term "psychopathic personality" as the best that has yet been devised, denoting such persons as are mentally abnormal continuously and not merely episodically and yet have neither a defect of intelligence on the one hand nor a psychotic conception of reality on the other. By common consent of all observers the denotation of whatever term is chosen is bound to be somewhat indefinite. The group of cases referred to is a very heterogeneous one. This is shown in practice by the wide variation in the proportion of cases to which the term is applied by different observers among different populations.

The following table, also from Partridge, illustrates this point:—

VARIATIONS IN THE PERCENTAGE OF PSYCHOPATHIC TYPES FOUND IN DELINQUENT POPULATIONS. (PARTRIDGE.)

	Cases	Per cent.
Glueck ... ..	608	18.9
National Committee for Mental Hygiene ...	1,288	42.2
Bingham ... ..	300	43.0
Stearns ... ..	107	12.2
Glueck ... ..	113	6.2
Raphael, <i>et al.</i> ... ..	1,988	36.8
Olsen ... ..	2,861	24.9

Such a variation in the estimate of the group among similar populations does not, however, seem so wide when one compares it with the variation in Kraepelin's estimate of the incidence of dementia præcox to the admissions to the clinics with which he was successively connected. It seems likely that if the same observers were observing the same populations, an agreement as to what constituted psychiatric personality might be far closer than the above table indicates. Where different kinds of population of psychiatric interest are concerned, the percentage incidence is widely different. Taking figures from the United States, where the term is in fairly general use, we find the following for the incidence of conditions connected with psychopathic personality.

ADMISSIONS TO THE BOSTON STATE HOSPITAL, 1920-1932

	Cases	Per cent.
Traumatic psychoses ... ..	26	0.52
Senile psychoses ... ..	709	14.13
Psychoses with cerebral arteriosclerosis ...	1,164	23.22
General paralysis ... ..	380	7.57
Psychoses with cerebral syphilis ... ..	25	0.50
Psychoses with Huntington's chorea ... ..	5	0.10
Psychoses with brain tumour ... ..	12	0.24
Psychoses with other brain or nervous diseases ...	89	1.77
Alcoholic psychoses ... ..	328	6.54
Psychoses due to drugs and other exogenous toxins ...	24	0.48
Psychoses with pellagra ... ..	3	0.06
Psychoses with other somatic diseases ... ..	147	2.93
Manic depressive psychoses ... ..	758	15.11
Involuntional melancholia ... ..	105	2.09
Dementia præcox ... ..	471	9.40
Epileptic psychoses ... ..	44	0.87
Paranoia and paranoid conditions ... ..	300	—
Psychoneuroses and neuroses ... ..	36	0.72
Psychoses with psychopathic personality ... ..	33	0.66
Psychoses with mental deficiency ... ..	136	2.87
Undiagnosed psychoses ... ..	164	3.27

Even here, evidently, such cases only receive admission when an episodic psychosis has complicated the picture of psychopathic personality. The percentage is not much more than a half of 1% of the admissions. But if we take a population that has come in contact with the police we find the percentage rising to 6½% as shown by the following table:—

ANALYSIS OF 576 UNCONVICTED CASES, MATTEAWAN STATE HOSPITAL, 1912

	Per cent.
Dementia præcox ... ..	41.4
Alcoholic psychoses ... ..	21.1
Epileptic psychoses ... ..	4.1
Paranoid conditions ... ..	6.9
Imbecility with excitements ... ..	7.1
Manic depressive psychoses ... ..	2.9
General paresis ... ..	2.4
Undifferentiated depressions ... ..	3.1
Constitutional inferiority ... ..	6.7
Not insane ... ..	2.2

The contrasting tables tend to emphasize that the importance of this group is pre-eminently a social one. At a time when psychiatry is progressively emerging from seclusion in institutions the need for paying greater attention to this group seems unquestionable.

The following two tables indicate the estimated percentage in a workhouse and gaol population respectively. It has to be remembered, however, that the conception some people have of what constitutes a psychopathic personality is too liberal.

ST. LOUIS WORKHOUSE, 178 CASES

Mental disorders:	
None ... ..	52
Subnormal intellectually ... ..	27
Borderline defectives ... ..	3
Feeble-minded ... ..	12
Psychopathic personality ... ..	59
Psychoses ... ..	2
Senile deterioration ... ..	3
Unclassified ... ..	3

ST. LOUIS CITY JAIL

	Whites	Negroes
Mental disorders:		
None ... ..	15	14
Subnormal intellect ... ..	4	17
Feeble-minded ... ..	2	10
Psychopathic personality ... ..	47	18
Epilepsy ... ..	0	1
Psychoses ... ..	4	0
Unclassified ... ..	4	2

An attempted delimitation of the group may well begin with the exclusion of allied syndromes. We can begin by excluding the psychoses and say that persons with the characteristics of psychopathic personality do not show frank psychotic manifestations except, at the most, episodically.

This at once raises a very definite problem, namely, the relationship of psychopathic personalities, whether of the schizoid, syntonio, or other types. There are, of course, deeper questions involved here, as regards for example the exact significance of the so-called psychopathic personalities, in view of the fact that only in a percentage of schizophrenic psychotics can it be demonstrated that something conforming to the characteristics of a pre-psychotic schizoid personality has existed.

Leaving such questions aside and assuming that prepsychotic personalities have been delimited and accepted, their relationship to psychopathic personalities in our

present sense must be considered. It appears that Kahn, for example, sees no very clear distinction between schizopathic personalities in this sense and psychopathic personalities. For example he says that the athymic and the sensitive types of dysthymic (psychopathic) personalities should be grouped in accordance with Kretschmer's theory among the schizoids. He adds the reservation "or at least should be brought into close contact with them."

Schneider, on the other hand, declares, on the ground of his clinical experience, that he cannot find transition forms between the psychopathic personalities and actual schizophrenias. In the year 1932, he says, "Among 189 schizophrenics and 359 psychopaths I could only find six cases in which the question of differentiation remained an open one to me." Schneider denies that he can see the transition advocated by Kretschmer from normal through psychopathic personality to schizophrenic psychosis. Similarly in the same year, with 50 cyclothymics and 359 psychopaths, there was only one case in which he felt undecided. Schneider's quarrel, however, seems to be rather with the idea of the possibility of any direct development of a personality towards a schizophrenic psychosis, i.e. the quarrel is with the relation of personality types to psychosis; so that all abnormal personalities can be grouped together, and it is unnecessary in Schneider's view to try to differentiate from them schizopathic or cyclothymic personalities. Universal agreement then consists in excluding only defect of intelligence and actual psychosis from the conception of psychopathic personality. The first tentative formulation of the group is that it is heterogeneous and that it consists of persons with a retarded organization of their personality beginning at any early age<sup>1</sup>, continuously disabling those afflicted persons from adaptation to life, to a greater or less extent, with discomfort either to themselves and/or with disturbance of their environment.

Classification can be attempted from two aspects, from the point of view of clinical description and from that of ætiology. Ætiology might itself permit of classification from various angles, either of apparent congenital endowment or of differences in individual psychological experience. The next table shows the suggested Kraepelinian classification which can be regarded as superseded by the more detailed study of Schneider. Schneider begins by dividing psychopathic personalities in this fashion, that they are such abnormal personalities as by reason of their abnormality suffer themselves or cause other people to suffer, the latter group being the so-called sociopaths. They are the members of the group which appear in statistical tables, the others by reason of lack of insight may fail even to come under medical observation at all. Schneider's division on a basis of clinical appearance including both groups is as follows:—

## CLASSIFICATION

*A. Kraepelin:*

Excitable.  
Unstable.  
Impulsive.  
Eccentric.  
Liars and swindlers.  
Anti-social.  
Quarrelsome.

*B. Schneider:*

Hyperthymic.  
Depressive.  
Insecure.  
Fanatic.  
Self-seeking.  
Emotionally unstable.  
Explosive.  
Affectless.  
Weak-willed.  
Asthenic.

The affectless in this classification are the principal contributors to the sociopathic group in a definitely anti-social sense.

If the categories of the various classifications are compared with one another it seems possible to discern some general similarities of a kind which suggest general

<sup>1</sup> An early age in the sense of the Mental Deficiency Act, 1927, means up to the age of 18.

concepts held in common by the various observers. Naturally a deduction of general characteristics which have appeared to all observers as possible differentia has to be discounted to some extent by a consideration of the influence which the various observers may have had upon one another through their writings. It seems that Kraepelin's group of excitable, unstable, and impulsive might be placed in the same category as the emotionally unstable, and the explosive, of Schneider, and also as the emotionally unstable, and perhaps the nomads, of the American Surgeon General's Office and as the sexual of other classifications. The hyperkinetic and hypokinetic in the classification of Blanchard and Paynter might also be included in this first group.

There is another general category which appears to have appealed to various observers, those called by Schneider the weak-willed and asthenic and by others the inadequate.

The value which cross references of this kind can have depends on the suggestions they make not only for general principles of classification but for ætiological theories upon which a classification can be based.

The general factors which have thus appealed to various observers have been used as a basis of classification by Kahn in the following way:—

#### PSYCHOPATHIC PERSONALITIES (Kahn)

##### A. From the point of view of impulse.

1. Impulsive psychopaths.
2. Psychopaths weak in impulse.
3. Sexual psychopaths.

##### B. From the point of view of temperament.

1. The hyperthymic.
2. The hypothyric.
  - (a) The athymic.
  - (b) The dysphoric.
3. The poikilothymic.

##### C. From the point of view of character.

1. Types of ego-overvaluation.
2. Types of ego-undervaluation.
3. The ambivalent types.

##### D. Complex psychopathic types.

1. Psychopathic instability.
2. Schizoid types.
3. The cold autists.
4. Sensitive psychopaths.
5. Anancastic psychopaths.
6. Hysterical personalities.
7. Hypochondriacal personalities.
8. Quarrelsome psychopaths.
9. Eccentric psychopaths.
10. Asthenic psychopaths.

This classification of Kahn's approaches an ætiological basis in the sense that it takes account of the apparent structure of the psychopathic personality and tries to subdivide various types according to which component parts of the personality appear to have been the dominating influence in producing the psychopathic end-result, or according to the point at which development seems to have gone wrong. There is first of all a class of impulsive psychopaths, as one would expect from the experience of previous attempts at classification; then in contrast he differentiates psychopathic personalities which, without necessarily any abnormality of intellectual endowment, seem to be characterized mainly by a deviation of development of the ego. In a third group another set of inborn tendencies, namely those which determine mood, dominates the psychopathic personality.

Any such grouping depends, of course, on one's conception of the structure of the completed personality. This classification of Kahn's is an attempt at charac-

terological analysis and is for that reason different from those previously mentioned which are purely symptomatically descriptive. It clearly postulates on the one hand an innate endowment of impulses, of a kind that no subsequent development of the characteristics of the ego has been able to manage satisfactorily. On the other hand it postulates some failure of development in the ego itself towards an average social level. The problem of the reasons for such an unusual and ultimately uncontrollable innate endowment in impulse and mood is to be sought presumably in heredity, in constitution, or in intra-uterine trauma of some kind. The problem of the failure of ego-development would be best probed by the methods of psychoanalysis or those akin to it, but unfortunately these patients rarely lend themselves to an investigation of that kind. At present a psychopath lends himself as a rule only to clinical description. Characterological analysis is only speculation.

Clinical inspection suggests that the following are the chief characteristics of the psychopathic personalities. The congenital endowment with regard to impulses seems to be one of either absolute or relative excess or defect of certain impulses, so that the pattern of the impulses is an abnormal and irregular one. The person thus endowed is confronted therefore, from the beginning, with a special problem of control. From the aspect of gratification, the psychopathic personality has an inability to postpone gratification, or, what is very much the same thing, an inability to stand deprivation.

As regards the organization of the personality from the aspect of the development of the ego, it can be said that this development never reaches an adult level, that is to say that the ego ideal is deficient in social components and has an excessively self-regarding or narcissistic appearance.

Symptomatically, psychopathic personalities are characterized by traits which could be dependent on such an underlying lack of organization and on unbalanced impulses.

An attempt to disentangle the more essential traits would place in the forefront lack of perseverance in effort, lack of foresight in the sense of wisdom, partial or complete lack of affection for others, and complete or partial impulsive self-satisfaction.

From these more fundamental traits there occur the following results: occupational instability, marital instability, economic insufficiency, extravagance, sexual excesses, alcoholism, and drug addiction and delinquency, in about this order of frequency.

Other characteristics are antagonism to authority with negativism, or, in others, extreme suggestibility, a tendency to blame others, and a more than average discrepancy of inferiority feeling on the one hand, and superiority on the other. In addition there are various characteristics such as untruthfulness, jealousy, boastfulness, a wish to domineer, and, on the other hand, in the inadequate types, shyness, self-pity, oversensitiveness, dreaminess, hypochondriasis and ready fatigue. It would be a good thing if someone would take a large series of psychopathic personalities, list and evaluate, with a quantitative estimate, their outstanding character traits and try to find out what correlations existed between the individual traits of behaviour, character and temperament. In such a catalogue the traits which make for sociopathic reactions are numerically probably more frequent than they should be because they attract attention so much more readily. This is well borne out by a parallel situation in a recent study of children attending schools, taking average samples of them, and contrasting the result with the types of children attending Child Guidance Clinics. The preponderance of behaviour disorders in the latter gave quite a false impression of the proportionate frequency of personality deviations to behaviour disorders in the average school population (McFie).

The problem of a *legal definition* of psychopathic personality is difficult and perhaps insuperable. Yet it may be necessary to arrive at some definition, partly

with a view to enabling some sort of control to be obtained over such persons before they have got into conflict with the law and while it yet seems possible to institute treatment of some kind, and secondly, in order to protect them after conviction from the full consequence of the law which would be visited on an ordinary person, or better, to ensure that the kind of consequence which would ensue would be likely to lead to a permanent improvement in their condition.

There is already in the law of this country a proviso about "moral deficiency" which is well known but which is almost, if not completely, a dead letter at the present moment. Burt has an able analysis of the existing legal definition in his book "The Young Delinquent." He points out that originally the suggestion by the Royal College of Physicians was that a person who shall be classed as a "moral imbecile" has displayed "from an early age in spite of careful upbringing strong vicious or criminal propensities." But the words "in spite of careful upbringing" were dropped and the words "mental defect, coupled with strong vicious or criminal propensities" were substituted by the members of the Royal Commission on the Care and Control of the Feeble-minded in 1908. ("An early age" as the result of the last Mental Deficiency Act is extended to include cases apparently originating as late as 18 years of age, and this is very desirable for our present purpose.) Burt points out that the words may mean, first of all, one who is primarily defective in intelligence but happens in addition to possess an incorrigible propensity to crime, dependent on the essential defect of intelligence; or they may denote a person whose incorrigible criminality is itself enough to constitute, or is itself an end-result of, an inborn mental defect. "In the first case it denotes an immoral defective, in the other case a person who is defective morally." The acceptance of the first interpretation renders the clause itself superfluous and places the moral imbecile in the category of the feeble-minded, a category which is already provided. At present the clause is interpreted almost entirely in practice in this sense and is consequently but little used. It seems that if it could become the practice to alter the interpretation to the second one, then a certain amount of provision would already exist in law for the most difficult kind of psychopathic personality. Incidentally it would become necessary to provide special accommodation for such a class of patient with a view to character training. But for some purposes a wider definition is required especially to embrace young psychopaths whose behaviour while not actually vicious endangers their own safety and prosperity as well as causing serious difficulty to responsible relatives. The broader definition which I would suggest tentatively and purely for discussion is as follows:—

*Constitutional psychopathy.*—Persons suffering from an early age from mental instability, not amounting to certifiable mental disease or deficiency, but characterized by emotional dullness or instability, together with a lack of perseverance, persistent failure to profit by experience and persistent lack of ordinary prudence, and resulting in occupational instability, marital instability, economic insufficiency, extravagance, sexual excesses, alcoholism, drug addiction, or delinquency.

*Diagnosis.*—How soon is it wise, for the patient's sake, to arrive at the conclusion that his personality is a psychopathic one? Much must depend on the duration of his symptoms, but, above all, on the effect of treatment. It must always be unwise to come to such a conclusion with regard to a young person, until the effect of some form of treatment has been tried over a considerable period. It is clear that in any such case such a diagnosis cannot be arrived at very early because one's conception of a child's or adolescent's personality is very much more fluid than one's conception of what an adult's should be. I have never yet certified a child as morally defective, but I have been willing to regard some adolescents as such in the legal sense, for technical purposes. By the time adult life is reached the malady is confirmed, as it were, and even without treatment the diagnosis may be permissible and desirable. The diagnosis must here depend on the history of sociopathic behaviour or of

inadequacy, together with a sufficient array of characterological, temperamental, or instinctual traits to account for that behaviour.

Before coming to this conclusion it is necessary to remember that a considerable change in an individual's personality may occur at some time in his life. Kretschmer has described a change in constitutional physical type at an age beyond early adult life. Similar spontaneous changes in the psychical sphere are probably more common at earlier ages. A shy and seclusive bookish youth may become a fairly sociable and determined man. Similarly with some psychopathic personalities nothing may be noticed till adult life. Here of course it may be that a person with an inadequate type of personality stands revealed ultimately by failure to take ordinary responsibility. In other instances in young persons the reverse change can occur and an apparently psychopathic personality become reasonably normal, judged by the touchstone of social efficiency.

The factors that may determine this change sometimes remain very obscure.

The following two cases of sisters with similar upbringing and similar characteristics, yet with very different outcomes so far, illustrate some of these problems. It is interesting that the sister who came under our care later in life than the other nevertheless did better.

Jane C. was one of a family of three, at an ordinary school. When she came to the clinic at the age of 14 years and 4 months it was stated that she was rebellious, did not attempt to work, led others into mischief and had recently played truant. Six months later the following report described her leading characteristics:—

"Owing to continued misconduct it has been considered advisable and necessary to ask for this girl's removal from the School. Her conduct has a degenerating (*sic*) influence on some of the girls of weak character. Each mistress who has charge of her finds that after a short period she becomes unmanageable unless allowed to have entirely her own way. Her temperament is apathetic and she is indifferent and insensitive to correction. She is somewhat callous as to the opinion of others and at most times in her manner shows a lack of response and want of interest. She recently again absconded from school, and on being brought back after some hours' absence she was openly defiant when remonstrated with and showed no signs of remorse at her conduct, although her companion was deeply sorry and showed real regret. Added to these delinquent tendencies is a growing persistence in lying. Her rudeness to her mistress has become so pronounced that the mistress feels compelled to resign her post unless some steps are taken to remove the girl. When remonstrated with over an offence she openly called her mistress a liar. When spoken to by the Head she was indifferent and defiant. It is a hard and baffling task to find any reason for her conduct."

Her subsequent history at other schools and on being placed out in certain jobs was unsatisfactory. She would do well for a while and then begin to show the old characteristics. Her sexual interests, which had always been prominent since she went to the Orphanage school, now became more definitely directed towards men. Two years later in 1933, in spite of instruction before being placed out, she had been guilty of misconduct and had frequently gone about with men, being by that time 17 years of age.

Her case contrasts with that of her sister May, whose age when first referred, in 1931, was 16 years and 9 months, i.e. she was two and a half years older than her sister when first sent to us for advice. May was said to be unable to concentrate, to wander off from jobs, to be sullen when spoken to; she did not seem to profit from experience, would disturb the other girls, said she hated domestic work and school discipline. She had no real friends and showed evidence of strong sexual interests. She used to be spiteful with younger children and there was one episode of truancy. Her intelligence quotient was 85, that of her sister being 90 on the Binet-Simon scale.

From her first job May was returned as slovenly, careless, impudent and negativistic. She deliberately destroyed things and was slow. With boys her conduct was unrestrained and alarmed her mistress.

A year later the following report was obtained :

"May was seen by worker on the 13th inst. From the first moment of meeting she chattered away freely, generally about her affairs at A. Her improvement in personal responsibility and stability was most marked. Another striking feature was her constant references to her upbringing at the Orphanage School and the obvious regard she had for her treatment there; for example she contrasts the free and easy discipline (under which she is so obviously thriving at her present home) with that of the school. She refers with pride to little things that she has learned to do, such as darning, for which she has been praised at A. Her standards are obviously taken over *en bloc* from them. She is one of the House Officers at A and as such enjoys a good deal of freedom. She has certain duties to perform but also a good deal of leisure."

The family background was of a father who had been sent to prison for assaulting young girls and a mother who had deserted the family and gone to live with another man.

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**Dr. Mayer-Gross:** The notion "psychopathic personality" was first introduced by a prison doctor, Koch, in a German monograph: "Psychopathic Inferiority." In this book the life-histories of a-social and criminal persons are described from a psychopathological point of view. Kraepelin adopted this name and the conceptions it embodies to make his system closer to the French conception of degeneration as expressed by Magnan. Kraepelin's use of psychopathic personality can be understood only by setting it in contrast to his notion of the gross psychoses as conditions, which lead to a destruction, or at least to a manifest change of personality—whereas the psychopathic reactions are a further development of the original personality, a blossoming-out of the character.

If, as in the English psychiatry of to-day, the psychoses and their symptoms are regarded as reaction-types, it is clear that this contrast disappears. Neurotic, obsessional, hysteric reactions are on the same footing with organic, schizophrenic, affective reaction-types. There is, it seems to me, no longer any place for the term "psychopathic personality," unless it is used in quite a different sense from that prevalent in Germany.

In fact, if it is proposed to adopt this notion, we must consider that everything depends on the point of view from which we look at the psychopathic facts. We cannot ask, what is true? We can only ask, What is fruitful?

Certainly from the therapeutic point of view, the English attitude, which emphasizes the role of the environment, is the better one. There is no doubt that the Freudian-psychology with the doctrine of reversibility of psychotic and neurotic symptoms, has had a considerable influence. On the other hand, every psycho-therapist looking over his cases without prejudice must recognize obstacles inherent in the original personality and quite irreversible. The task of the therapist must be to bend the twigs of personality and make them grow in a more social direction. In these cases we think that the predisposition, the "Anlage," is so preponderant, so decisive in every situation, that the root of the matter lies in the abnormal character and we speak of a psychopathic personality.

One might say that this point of view has been extended too much in German psychiatry and has sometimes led to a sort of therapeutic nihilism. A contrary movement has been going on for the last few years.

As to the ætiology of the psychopathic personality I would suggest that it cannot be considered apart from the question of the origin of the variations of the normal personality. Indeed, all the psychopathic types described by Schneider can be regarded as caricatures of normal types shading into them with no sharp demarcation. This certainly does not answer the ætiological problem—but it emphasizes the difficulties one meets, when one tries to separate sharply innate from acquired or environmental factors.

**Dr. J. R. Rees:** I have found the literature of this subject far from clear and not at all helpful. It would appear that certain writers like Bleuler would include in the group that we are discussing to-night all aberrations of the sexual impulse: masturbation, homo-sexuality, fetishism, criminality (a large word), dipsomania, the gamblers, liars and swindlers and enemies of society. This list in fact covers practically all the so-called moral disorders, and to most of us has no meaning, for we recognize that the majority of these conditions are curable. Dr. Hamblin Smith's paper in the *Journal of Mental Science*, 1925, lxxi, 683, is a very useful contribution. Every practising psychiatrist knows the limitations and difficulty of the psychopathic personality. These patients have the inability to make social adjustments, they fail at everything they take up, they are inadequate, often paranoid, often "shut in." At the moment I have three such patients under my periodic care, and it happens that I have had two or more members of each of their families as patients, and so have some insight into the family background. One of them has no psychopathic family history, but he suffered from a dominating father and a weak and indulgent mother; he was the eldest of six children. The second has a family history of eccentricity; his father was apparently normal, his mother a psychoneurotic. His own family, of which he was the youngest, contains one brother—the eldest—who is a certified case of dementia præcox, the eldest sister who was a psychopathic personality and three other sisters who are mildly so. The third has no bad heredity save an obsessional and Jehovah-like father. He is the youngest of four; the eldest brother was a mild psychopath, the sister, next, had a neurotic breakdown and is apparently completely cured; there is one other brother who is fairly normal. Despite the psychopathic history of these last two patients, I rather doubt the inheritance of their psychopathic traits. The position in the family and the environmental factors seem to me probably of more importance. Environmental difficulties are, on the whole, more clearly emphasized in the better-off section of the community than in the working-class families, and such experience as I have shows that the name "constitutional psychopath" is more often given in private work than in Clinic practice.

At the Institute of Medical Psychology the diagnosis of psychopathic personality is one of the rarest; this may, of course, be due to idiosyncrasies of the various physicians. There are no real statistics available, but Dr. Marjorie Garrod and Miss MacFarlane have hurriedly compiled some figures for the purposes of this meeting. If constitutional psychopaths attend the Institute—as presumably they do—they must be numbered amongst the psychotherapeutic failures, and it is to them that we have directed our interest.

A group of a hundred consecutive cases have been worked out; most of them have been followed for at least two years after discharge. They are divided into two groups: (a) the cured, or those in whom improvement has been maintained; (b) those who have not improved or have relapsed. The proportions of these groups are 65 to 35.

The following are the only relevant figures that I can get from the careful tabulations:

	Improved Group	Unimproved Group
Psychopathic heredity	81%	63%
Bad environment in childhood	44%	58.5%
"Mental" illness in childhood	29%	57%
Parental discord as one factor in family environment	8.6%	21.4%

Obviously these numbers are very small, and neither the records nor the figures can pretend to statistical accuracy.

A group of the last fifty cases discharged from the Children's department of the Institute is just as negative in its emphasis on inherited factors. Of these 50 children, 19 had a psychopathic heredity (3 insanity, 12 neuroses, 3 alcohol, 4 delinquency), 4 had a bad physical heredity. Eleven of the children had some physical defect. Of the 50 children 10 were labelled "instability," and it might be presumed that the constitutional psychopaths were in this group. Of these 3 had suffered from physical troubles and 4 had a psychopathic heredity (1 insanity, 3 neuroses).

In the group of 50 children there were 14 delinquents. As regards their psychopathic inheritance, there was no history of insanity. One had a psychoneurotic parent, three had a family history of alcohol, three a family history of delinquency. Two of these delinquent children had suffered from physical disorders—one from a congenital heart disease and one from delayed teething. It is interesting to note that of the 14, three were institution children, and two were illegitimate and that parental discord was the main factor in one other case.

For what little they are worth, these figures seem to point to the importance of upbringing and the environmental factors rather than to innate or constitutional causes.

I would suggest that the term psychopathic personality is one which is largely applied to our failures—those who did not respond to treatment—and that it might tend, if widely used, to become a dumping-ground. There would be real danger if the giving of a name precluded serious attempts at treatment. I feel that the psychopathic personality is primarily a psychopathological phenomenon. If the children's clinics do their work well, we should have less use for this term in the future.

**Dr. Murdo Mackenzie:** Post-graduates who study psychiatry are of two kinds, the intelligent and the unintelligent. The intelligent find the subject difficult and even after careful perusal of case notes and prolonged examination sometimes state that they are unable to describe the clinical nature of the disorder or the character-type of the patient.

This is not the case with the unintelligent who, when asked the nature of their findings on examination, state with confidence and an air of finality that "the patient possesses the psychopathic personality." A retreat to "Henderson and Gillespie" in such circumstances is both right and proper. The position as revealed in that admirable textbook seems to indicate, among other things, that the possessor of a psychopathic personality tends, either through poor inheritance or bad training, to develop mental disorder to a permanent or temporary degree and that such disturbance is an exaggeration of the normal condition of the individual.

In view of the fact that the patients under discussion were inmates of Bethlem Hospital, it seemed reasonable to agree that they were probably suffering from mental disorder to a temporary or permanent degree but also important to suggest that a closer assessment of their normal condition would be profitable.

The subject has undergone considerable elaboration, and from the opening paper in this discussion it appears that no general agreement has been reached about the delimitation of this group, that the ætiology is obscure, and that treatment is characterized by limitations rather than by possibilities. This suggests that it

cannot be established as a clinical entity, and therefore there is no underlying psychopathology. Further, in view of the limitations of treatment, no prognosis can be given.

Such a point of view is of course no difficulty to the uprising young men of modern psychiatry since they have caught hold of the term and will not let it go lightly. What does it mean to them? It may mean an M.D. thesis in these days when the medical profession is being bullied into accepting psychiatry with its psychological ramifications as a serious matter. It *does* mean literary venture, for the term possesses all the requisites of the modern medical article. There is the preamble concerning the previous writings on the subject; that is knowledge. There is the possibility of running a tape-measure over a willing or unwilling patient and making an exact measurement; that is science. There is the discussion, preferably illustrated by personal experiences in America; that is originality. There is the summing-up, with the pros cancelling out the cons; that is safety. Where there is knowledge, science, originality, and safety, what medical editor dare say "No"?

Such literary ventures are, however, for the complex, who matter, and who must be encouraged, with their intellectual dexterity, their mass of irrelevant detail, and their joy in confusing issues.

The simple, of course, do not matter, are not encouraged, and merely have an irritating way of going on existing. To these the term "psychopathic personality" suggests that the type of any mental disorder, which depends for its clinical recognition on affective disorder rather than on organic change, is determined by the original personality of the individual. Hence, given instability and environmental difficulties, the cautious become depressed, the wary suspicious, the aggressive maniac, and the exotic hysterical.

This outlook is, of course, intolerable to the complex uprising psychiatrist whose manifold possibilities can only be guessed. It is, however, the authoritative point of view of the simple.

**Dr. C. P. Blacker** said that, by reason of their failure to adjust themselves to the requirements of society, psychopathic and sociopathic persons who were not supported by the social life-belts of inherited wealth and influential relatives, tended to sink in the social scale. The "social problem group," referred to by the Wood Committee, largely consisted of such persons. An investigation was being conducted, the object of which was to define more clearly the characteristics and delimitations of this group.

He (Dr. Blacker) questioned the possibility of distinguishing, as clearly as had been suggested by previous speakers, between the influence of environment and that of heredity in the genesis of the psychopathic personality. In a given instance, the environment had been held responsible for this by a previous speaker, because the psychopathic person had been brought up in an atmosphere of parental discord. But failure to make a satisfactory adaptation to married life was one of the characteristics of the psychopathic personality. It was therefore not impossible that the parents in this case were mildly psychopathic. By the same speaker, environment had also been held responsible for abnormalities developing in several children whose father had evinced aggressive and self-assertive characteristics. But the description of the father suggested that he was himself a mildly abnormal person.

It was extremely difficult to evaluate clearly the rôle of heredity in the causation of psychic abnormalities. Where was the line to be drawn between normality and abnormality among ancestors and collateral-relatives, and how far should the net be cast in making investigations? It was very difficult to standardize inquiries of that kind, and in order to achieve comparable results, the material had to be subjected to mathematical analysis. Thus, much would turn on whether the father and the mother or the grandparents had few or many brothers and sisters. The more

numerous their brothers and sisters, the greater the chances of abnormalities appearing. Thus, a given psychopathic person might be thought to owe his abnormality to heredity, if two of his father's sisters had suffered from epilepsy and one of the father's brothers from insanity. But if the father had been an only child, or if all his brothers and sisters had died in infancy, there might be no evidence of hereditary causation in the case in question. If the net was cast sufficiently far back among ancestors and sufficiently widely among collateral relatives, abnormal persons would almost certainly be found. No one had yet satisfactorily laid down how far the net should be cast; nor was it agreed as to what abnormal conditions occurring among ancestors and collateral relatives causal significance should be ascribed.

**Dr. E. B. Strauss.**—The concept of constitutional psychopathy is not only useful but perhaps, in our present state of knowledge, indispensable. The observation of individuals in institutions as different from each other as an ordinary "nerve clinic," a mental welfare hospital, a reformatory school and a hospital for functional nervous disorders confirms this impression. But one should realize that in considering constitutional psychopathy one is dealing with a group of conditions and not a single constitutional anomaly—this would seem to be Partridge's chief error. The other authorities quoted by Dr. Gillespie—Kraepelin, Schneider and Kahn—also muddle us, because all the schemes which they have elaborated take account of widely different aspects and functions of the personality. Kretschmer's classification of the psychopathies is possibly the most helpful, because it is consistently based on the factor of temperament. Kretschmer classifies the constitutional psychopathies under the heads of schizoid, cycloid, epileptoid, and hysterical. In studying temperamental differentiae, he takes stock of mood, psychic tempo, psychomotility and specific behaviour-patterns and psychophysical peculiarities (e.g. tendencies to "short-circuit reactions," intolerance of alcohol, impulsive running away and the like). Mental defectives form a group by themselves and it is disadvantageous to include them in the group of the constitutional psychopathies. The study of the temperamental peculiarities of mental defectives is not very helpful, as these persons tend to exhibit a certain temperamental uniformity due, in the speaker's opinion, to a temperamental stunting analogous to the other forms of developmental arrest from which they suffer. So-called "moral defectives" (in the absence of intellectual defect) are, in my opinion, usually identical with schizoid or epileptoid psychopaths (or admixtures). It is perhaps not altogether correct to state that psychopaths are unresponsive to psychotherapy. That statement would probably be true if one were to limit psychotherapy to analytical methods. If the term is made to include methods involving character-training and discipline (as practised at Besford Court Mental Welfare Hospital, for instance), there appears to be evidence that much good can be done by psychotherapy.

**Dr. Noel Burke** said that in work on "shell-shocked" men after the War, it was obvious that there were some who had been exposed to shell and other stresses of warfare for four years before they broke down, whereas others had a nervous collapse on receiving news that they were merely on draft for the Front. To his mind these were the constitutional psychopaths, and he believed that they should be regarded as exactly what the name implied, people who, by constitution, were unduly prone to mental illness, that is to say, those who could not maintain mental health in the face of the ordinary rough-and-tumble of life. If this was so, he doubted if Dr. Gillespie was justified in excluding at the one end the certified psychotics or the psychoneurotics, who were merely extreme cases, as they were probably all constitutional psychopaths. At the other end of the scale, some high grade mental defectives were exactly described by the picture put forward by the opener, and might fairly be included. The picture fitted equally well the typical

post-encephalitic defectives, but their aetiology served to exclude them from the group, as their condition was purely acquired.

**Dr. W. C. M. Scott.**—One of the most disheartening statements made in case-discussion is one including a jump from the diffuse details of the total material to the single word "psychopath" with or without the heredity tag. My orientation to the field came first through Meyer and Healy. Meyer's 1903 paper on "Neurotic Constitution" led to his later formulations in which specific descriptive characterizations tended to exclude vague concepts. In the late 'twenties Healy, Kasanin, and Clark, using the material of the Judge Baker Foundation, attacked the problem of formulating abnormal personalities and found a rather small percentage of the total material not subject to formulation in descriptive or descriptive dynamic terms along the line of already established psychotic or neurotic reaction types.

The small number left varied sufficiently to lead to the following groupings. (1) Individuals who, owing to some physical handicap, are misfits, but without characteristics which would make one think that they would be misfits in the absence of the physical handicap. (2) Individuals who are misfits due to uncomplicated emotional lability. In these, reactive anger, passion, depression, etc., lead to difficulties. (3) Individuals who are eccentric and in whom the oddities of behaviour do not markedly interfere with adaptation. (4) Individuals who for continued periods have appeared to be on the verge of a more florid psychotic reaction but whose behaviour those in charge hesitate to call psychotic.

The value of this work seemed to me to be the demonstration of the small number of cases not adequately formulated in other ways and of how those not so formulated brought to the forefront two problems. First, the problem of the breadth of our concept of psychosis, and secondly the problem of neuroses whose symptomatology is seen to a large extent in the social setting and less in the merely personal. The first problem is strikingly seen in the varying attitudes towards the dementia præcox, schizophrenic, or parergastic reactions. Those who formulate in terms of an absolutist psychopathology see many psychopaths, whereas those who formulate in more relativistic terms see a series of reactions including all degrees of malignancy, involvement, etc. And here I agree with Dr. Mayer-Gross when he remarks on the outlook determining the need for the concept we are discussing. With regard to the second problem, that of neuroses with social symptomatology presenting, which includes the problem of most of the delinquents, I think that any degree of intensive investigation soon shows how the presenting symptoms are related to other types of symptoms no less personal than those in any neurotic whose complaints are almost solely personal. When such considerations are kept in mind, therapeutic problems can be related to the problems of therapy of any psychopathological phenomena.

**Dr. T. S. Good** suggested that Dr. Gillespie had really hoped that in this discussion he would find an explanation of the term "psychopathic individual." A solution of the problem might be reached by investigation on the lines of Kretschmer, Wertheimer, and Hesketh, namely by observation of types and anthropometric measurements; he agreed with Dr. Strauss that these methods were of great importance in investigating temperaments.

He thought that a solution might also be found by experience in Child Guidance Clinics.

**Dr. Isabel Wilson** said that it would be of great interest to study children in nurseries and children's hospitals in order to see whether any constitutional factor on the Kretschmer lines could be found to account for the very great differences in the behaviour of different children in the face of difficulty in the environment.

Quite young children and even infants would sometimes show retreat and negativism to a severe degree before some apparently trivial difficulty: was this all to be accounted for on psychological lines, or were there important physical factors also?

## Section of the History of Medicine

President—Sir STCLAIR THOMSON, M.D.

[March 7, 1934]

### The History of Hæmatology

By Sir HUMPHRY ROLLESTON, Bart., G.C.V.O., K.C.B., M.D.

THE word "hæmatology," which appears to have been first used in this country in 1811, is older than might be expected, for in 1743, Thomas Schwenneke (1694-1768) wrote *Hæmatologia, sive Sanguinis Historia, Experimentis passim superstructa etc.* Hagæ Comitum. Hæmatology, like bacteriology, has developed as the result of laboratory methods and the applications of physics and chemistry. There is a resemblance between the evolution of surgery and that of hæmatology; in the case of the surgeon's craft the advent of anæsthesia in the middle of the last century greatly facilitated the performance of operations, but eventual success was deferred until Lister's teaching was accepted and practised. The invention of magnifying lenses and microscopes which, with their progressive improvements, especially the compound achromatic form of microscope invented by G. D. Amici (1786-1863) of Modena a hundred years ago, was the first step in making it possible to see the solid constituents of the blood, long preceded any real knowledge of hæmatology. It is wonderful what Antonj van Leeuwenhoek (1632-1723) of Delft saw even with his own lenses.

The difficult subject of the early history of the microscope was set out in detail in May 1914 by Dr. Charles Singer. The name "microscope," like that of the telescope, originated with the Accademia dei Lincei (Lynxes) and was used in a letter written by Giovanni Fabri (Faber) in 1625 (Govi).

The effective activating factor in the evolution of hæmatology was the method of staining introduced by Paul Ehrlich (1854-1915) who when a student began to use aniline dyes in histological work; starting this work in 1877 he two years later published his work on the specific granules of the blood-cells, which he classified as they are now known.

Many may have wondered why the arteries, as the word implies, were for so long considered to contain air and not blood. Aristotle (384-322 B.C.) believed that the arteries contained blood, but Erasistratus (c. 300 B.C.), described as "the father of physiology," taught that, whereas the veins carried the blood, the arteries were occupied by the "vital spirit"; like Aristotle he assumed synastomoses or communications between the arteries and veins; but this was mainly to explain why an incised artery gave out blood. As Crawford expressed it, Erasistratus, the surgeon, who knew that blood issued from a severed artery, found himself in conflict with Erasistratus the physiologist who held that arteries contained air, and was therefore driven to the elaborate and certainly ingenious hypothesis, which his contemporary Praxagoras of Cos also professed, that when an artery was opened the pnuma or air escaped and, to prevent the vacuum abhorred by nature, normally closed communications between the arteries and veins opened and allowed blood to fill the wounded artery. Galen (A.D. 131-200), who in many ways so nearly anticipated Harvey in the discovery of the circulation, recognized that the arteries contained blood. There is a quite modern analogy to the belief that the arteries, which are empty or nearly so after death, contained air; it is in connexion with the position of the stomach and other abdominal viscera during life. Until recently

it was thought to be that found after death, namely almost transverse. Since the introduction of opaque meals, radiologists, particularly A. E. Barclay, have shown that the normal stomach is usually J-shaped and vertical in position, except for the pyloric end, and have established the extraordinary mobility of other parts of the intestinal tract during life.

Harvey (1578-1657), in 1653, regarded the blood as a "living element of the body . . . the first to live, the last to die," and so did John Hunter (1728-93); this has long been shown to be true for the corpuscles, and in 1886 L. C. Wooldridge (1857-89) concluded that the plasma is protoplasm and undergoes necrosis on clotting.

Probably from the influence of the old humoral doctrines, the chemistry of the blood was at first more generally investigated than its histological structure; thus the most important medical book of Robert Boyle (1627-91), who was created "Doctor of Physick" at Oxford in 1665, namely that *On the Natural History of humane Blood*, published in 1684, summarized the existing knowledge of the chemistry of the blood. In the eighteenth century the short-lived William Hewson (1739-74) investigated the coagulation of the blood, microscopically examined the corpuscles, and not only gave the first good account of the origin but was probably the first to recognize the existence of the colourless blood-cells. In the "hungry forties" of the last century when venesection provided such oceans of blood, much attention was directed to its clotting and especially the buffy coat, which recalls the modern sedimentation test. Andral (1797-1876), with the help of the chemists Jean Baptiste Dumas (1800-84) and Jules Gavarret (1809-90), analysed the blood as regards its contents of fibrin and albumin, and microscopically examined the blood in anæmia,<sup>1</sup> recognizing that there were various forms, among them that due to lead poisoning, and brought out his *Essai de l'hématologie pathologique* in 1843. Almost at the same time Carl Rokitsansky (1804-78) upheld humoral pathology by speculative descriptions of "crases" of the blood. At this period Alexandre Donné (1801-78) was active in the microscopical examination of the blood, and William Addison (1802-81), M.D., F.R.S., surgeon to the Duchess of Kent, of Great Malvern and subsequently of Brighton, was, in 1907, hailed by H. A. McCallum of London, Ontario, as "the world's first hæmatologist"; this was on account of his observations on the blood corpuscles—especially the leucocytes—which are mainly contained in a rare tract of 76 pages published in 1843: "Experimental and Practical Researches on Inflammation and on the Origin and Nature of Tubercle of the Lungs."

As showing the comparatively recent origin of differential hæmatology, it may be mentioned that in 1880 Arthur Gamgee (1841-1909), who was most anxious to link up laboratory work with clinical practice, wrote that the attempt to establish a distinction between the changes in the blood in chlorosis from those in other forms of anæmia is most artificial and useless; Sidney Coupland (1849-1930), in his Goulstonian lectures in 1881, said that it was seldom possible to diagnose chlorosis from pernicious anæmia. On the other hand the extensive separation of different types of disease of the blood-forming organs, which has gone on apace during the last half-century, has shown some sign of a reaction in the linking up of forms of disease at one time regarded as distinct. Thus chloroma, originally thought to be an ordinary malignant new growth, is now known to be a form of leukæmia; the anæmia in middle-aged women at one time regarded as a secondary anæmia was put in a different category by Knud Faber in 1913 and by Wits in 1930; the latter, calling it simple achlorhydric anæmia, showed that though hypochromic it was allied to the hyperchromic Addisonian anæmia. Quite recently Gaucher's disease

<sup>1</sup> *Anæmia* (want of blood) was used by Aristotle (384-322 B.C.); but according to Sir Thomas Watson (*London Med. Gaz.*, 1840-1, n.s. i, 99), anæmia was first employed medically by Andral who also invented the word hyperæmia. It seems to have first appeared in English in 1836 in the *Cyclopædia of Anatomy and Physiology*, edited by R. B. Todd (1809-60).

and the closely related Niemann's disease have been thought to be forms of lipid histiocytosis and so connected with other manifestations of xanthomatosis, in which the reticulo-endothelial system is infiltrated with lipoids, such as amaurotic family idiocy (vide p. 40).

Microscopical and other methods of investigating the structure and functions of the blood, especially Ehrlich's work and stains, have revolutionized hæmatology in the past fifty years and created a nomenclature almost as formidable as that of dermatology. New facts are constantly brought to light and may necessitate revision of knowledge previously regarded as fairly settled, for example, the origin and relations of hæmoglobin are again under discussion; it was in this connexion that Professor Joseph Barcroft quoted a previously unpublished comparison, made by his predecessor at Cambridge, Sir Michael Foster (1836-1907), of the growth of knowledge to the ascent of a spiral stair from which the observer periodically surveys the same landscape, but each time from a higher level than the last.

*The erythrocytes.*—Jan Swammerdam (1637-80) of Amsterdam saw the red blood-corpuscles as early as 1658, but this observation did not attract attention until his great *Bybel der Natuur*, or history of insects (1669), was translated into Latin, with a preface by Boerhaave, in 1738. Marcello Malpighi (1628-94) of Bologna in 1661, the year he was the first to see capillaries in the lung of the frog, saw the red blood-corpuscles in the blood of the hedgehog, but regarded them as fat globules, and did not interest himself further in them. He used a primitive microscope, probably that invented in 1590 by Zacharias Joanides (Jans) and his son of Middelburg, Holland. Antonj van Leeuwenhoek, the "father of microscopy," in 1674 saw and correctly described, with illustrations, the red blood-corpuscles in man and many animals, and stated that "the blood consists of small round globules driven through a crystalline humidity of water," and that the small round globules were heavier than the crystalline water. From careful measurement he found that the diameter of human red corpuscles was  $7.5\ \mu$ , an estimate which has always been accepted. They received various names; G. P. Bidloo (1649-1713) in 1685 called them "vesicles," as did others, and their spherical form was not questioned until 1749, when J. E. de Senac (1693-1770) stated that they were discs; William Hewson independently in 1773 also measured them and said that they were "as flat as a guinea." These observations, however, did not gain acceptance; the corpuscles were described as merely air bubbles, and in 1813 Thomas Young (1773-1829) measured these "coloured particles" and rather scornfully dismissed the view that they were "as flat as a guinea." Probably George Gulliver (1804-82), who edited and annotated Hewson's works in 1846, really established the reliability of Hewson's observations.

The red blood-corpuscles were thought by Hewson in 1773, and by Donn  in 1842-4, to be developed from the leucocytes, and this was maintained far into the last century; for example in 1852 Hughes Bennett stated that the white cells were transformed into red cells in some unknown way. Hayem (1841-1933) in 1877 believed that the platelets became erythrocytes and continued to urge the view that they regenerated the blood in 1923. E. Neumann (1834-1918) and Bizzozero, both in 1868, showed that the mature erythrocytes were derived from normoblasts (nucleated reds) in the bone-marrow.

Poikilocytosis was described by Quincke (1842-1922) in 1875. The increased fragility of the erythrocytes to hypotonic saline solutions was published in 1907 by A. Chauffard (1855-1932) in hereditary acholuric jaundice which had previously been described clinically in this country by Claude Wilson in 1890 under the name of "hereditary enlargement of the spleen," the blood being stated to be normal; it was also described in 1900 by O. Minkowski (1858-1931) to whom the credit has generally been given.

Enumeration of the corpuscles was based on the method employed by Karl Vierordt (1818-84) in 1852, namely dilution of a measured quantity of the blood and

counting the corpuscles contained in a certain volume of that dilution. Vierordt estimated the number at five million per cubic millimetre in male human beings. L. Malassez (1842-1909) in 1874 designed an apparatus which was successively modified in 1875 by Hayem and Nacet, and in 1877 by Gowers (1843-1915) who introduced the name hæmocytometer; this was in its turn superseded by the Thoma-Zeiss instrument.

*Hæmoglobin.*—The colouring matter of the red blood-corpuscles was first regarded as hæmin or hæmatin, the crystals of which were first seen by K. B. Reichert (1811-83) in 1849; these were shown in 1868 by Hoppe-Seyler (1825-95) to be a crystalline product of the real colouring matter, hæmoglobin. Hæmatoidin crystals had been figured by Sir Everard Home (1756-1832) in 1830 and were given their name by Virchow in 1847.

*Hæmoglobinometers.*—Hoppe-Seyler worked with a hæmatinometer; this was modified in 1877 by Malassez, in 1878 by Gowers, and in 1901 by J. S. Haldane, who substituted a standard solution of CO-hæmoglobin properly graduated for that employed by Gowers.

*Blood groups.*—In 1901 Landsteiner classified three groups, in 1907 Jansky described four groups, and 1910 Moss confirmed this.

*The platelets, hæmatoblasts, thrombocytes.*—These elements of the blood have been independently described by a number of observers. Alexandre Donné in 1842 gave an account of them under the name of "globulins" of the chyle, measuring  $\frac{1}{800}$  of a millimetre, but he admitted ignorance of their origin, a problem still unsettled. In 1841 William Addison, in 1842 possibly Wagner, and in 1843 Andral may have seen them in commencing clotting of the blood, and Andral in chlorosis. G. Zimmermann (1817-66) in 1848 gave a more detailed description of them. There was then an interval until 1865 when Max Schultze (1825-74) found them constantly in his own blood and that of other healthy persons. Riess in 1872 regarded them as the remains of disintegrated leucocytes, and in the same year Vulpian (1826-87) pointed out that they were more numerous than the leucocytes. In June 1874 Osler's paper on "Certain Organisms occurring in the Liquor Sanguinis" was read before the Royal Society; he had noticed movements, but did not, as the title might suggest, regard them as bacteria, for "as there is no evidence that these bodies are in organic continuity with any other recognized plant or vegetable form or possess the power of reproduction, nothing can at present be said of their nature or of their relation to bacteria"; he noted that white thrombi were almost entirely composed of them. In 1877 Hayem called them hæmatoblasts, or the third element of the blood, and insisted that they were the early stage of red blood-cells and regenerated the blood, a view he maintained again in 1923. In 1879 R. Norris (1830-1916) of Birmingham described an "invisible or third corpuscle of the blood" which was a white cell on the way to become a red blood-corpuscle and was of the same size as the red cell; he regarded Hayem's hæmatoblasts as the discharged granules of the invisible cells. Löwit (1851-1918) in 1884 had regarded them as the debris of leucocytes and not as formed elements. Guido Bizzozero (1846-1901) in 1882 gave them the name of platelets, and recognized that they played a part in the coagulation of the blood; Muir examined them in 1891; Deetzen and Dekhuyzen called them thrombocytes in 1901; and Homer Wright in 1910 concluded that they were budded off from the megakaryocytes in the bone-marrow.

*The leucocytes.*—In the absence of reagents, such as acetic acid, and especially of stains, the existence of colourless, as distinct from red blood-corpuscles was long delayed. J. E. de Senac in 1749 mentioned the *globules blancs du pus* as belonging to the chyle, and in the second edition of his *Traité de la structure du coeur*, brought out in 1774 by Baron A. Portal (1742-1832), it is implied that Leeuwenhoek had seen them in the previous century, a statement also made by R. Wagner in 1842. But in the 1783 edition of Senac's treatise it is suggested that what the Dutch

microscopist really saw were erythrocytes. However this may be, William Hewson described them in 1773 as derived from the lymphatic glands and thymus and poured by the thoracic duct into the circulation, thus eventually reaching the spleen, where they became transformed into red blood-corpuscles.

Alexandre Donné in 1842 considered that there were in the blood three kinds of corpuscles, namely the white which change into the red, the red, and the globules of the chyle. In the same year Andral described the white corpuscles, but did not regard the pus cells as leucocytes, and Rudolf Wagner (1805?-64) agreed with the view expressed in 1773 by Hewson and in 1835 by C. F. Nasse (1778-1851), that the leucocytes become transformed into red blood-cells. William Addison in 1840-3 using a magnification of 250 to 500 made a number of observations, especially in the tract published in 1843, which have been almost entirely forgotten; he gave an account of different kinds of leucocytes and pointed out the presence of included granules. He stated that the leucocytes formed the pus cells, but went much further and agreed with the opinion of Martin Barry (1802-55) in 1840 and 1841 that all epithelial cells are derived from the colourless cells. Wharton Jones (1808-91), the teacher of Huxley at Charing Cross Hospital and of Lister at University College Hospital, disliked the term colourless cells and divided them into non-granular and granular, the latter being finely or coarsely granular in 1846. Schultze in 1865 described four forms of colourless corpuscles in human blood and recognized those finely or coarsely granular. Ehrlich's work from 1879 enabled him to recognize six varieties and, as already pointed out, formed the basis of the present classification of the white blood-corpuscles. In 1883 he established the origin of the granular leucocytes in the bone-marrow.

As Professor William Bulloch told me some years ago, the word "leucocyte" made its appearance first in 1855 in M. P. Littré and C. Robin's *Dictionnaire de médecine* (Nysten); it was probably suggested by, and derived from, the word *leucocythémie* employed in 1851 by Hughes Bennett (1812-75) in a paper read before the *Société de biologie* in Paris, to describe "white-cell blood."

William Addison in 1843 described an increased number of hæmic leucocytes in scarlet fever and in the blood taken from the neighbourhood of a pimple or a boil, and so gave the first hint of leucocytosis, but his observation did not attract any attention. The word "leucocytosis" was constructed by Virchow in 1858. The increased number of leucocytes found in 1845 by Hughes Bennett and Virchow in leukaemia stimulated a search for its presence in other diseases. Wilks in 1855 published a number of cases of various diseases in which he had examined the blood, but in one only, a case of fever, was there any increase. Enumeration of the white blood-corpuscles was first, and until after Ehrlich's work in the decade 1880-90, estimated by their proportion to the number of reds, the normal being regarded as 1 white to 300 reds.

Amœboid movement in the white blood-corpuscles was described by Thomas Wharton Jones in 1846, Davaine (1812-82) in 1850, Lieberkühn in 1854, and von Recklinghausen (1833-1910) in 1863. In 1859 William Addison gave an account of the diapedesis and stasis of leucocytes in inflammation, thus anticipating this observation made in 1868 by Julius Cohnheim (1839-84). Ernest Haeckel (1834-1919) laid the foundations of the theory of phagocytosis, which, from 1882, Elie Metchnikoff (1845-1916) elaborated, introducing the word "phagocytosis" in 1886. Attention was called by Panum (1820-85) in 1874 and by K. Roser in 1881 to the part phagocytosis might play in immunity. The rival claims of the wholly phagocytic hypothesis of immunity and of the humoral school outlined by G. H. F. Nuttall, H. Buchner (1850-1902) and others, were critically considered and balanced by A. A. Kanthack (1863-98) and W. B. Hardy (1864-1934) in 1893.

Arneth Count: In 1904 Joseph Arneth distinguished five groups of polymorphonuclear leucocytes, according to the lobes of the nuclei, and advocated the estimation of these groups as of value to the detection of microbial infection. This method was modified by Schilling in 1911 and by W. E. Cooke in 1914.

*Chlorosis.*—The statement that cases of anæmia in young women are to be found in the Hippocratic corpus has been disputed. Hirsch tells us that Oribasius (A.D. 325-403), Aetius (c. 500), Avicenna (980-1037), and the school of Salerno (c. 1000) recognized the combination of pallor, dyspnoea and weakness on exertion, and amenorrhœa. The best early description was given in 1520 by Johann Lange (1485-1565), the published account being in his *Epistolæ medicinales*, Bâle, 1554, under the name "morbus virgineus." It was also known as "febris amatoria" and "icterus amantium," suggesting thwarted sexual instincts, and as the "green sickness" and "poorness of blood." The name chlorosis which, according to Hirsch, had been used by the Greeks in a somewhat different sense, was first applied to the disease by Jean Varandal (*ob.* 1617), professor of medicine at Montpellier, and appears in his posthumous works published in 1620.

Andral in 1843 described the red cells as smaller than normal, and also fragments which may have been platelets, the increased number of which was reported in 1891 by R. Muir. Bouillaud (1796-1881) in 1841 invented the term *bruit de diable*, regarding it as arterial and not as a venous murmur. In 1855 F. R. Rilliet (1814-61) gave an account of febrile chlorosis imitating pulmonary tuberculosis, a condition which he said had escaped the notice of Laennec, Louis and Andral. Discordant views about the relations of chlorosis and tuberculosis succeeded each other; they were thought to be antagonistic, that in 60% of chlorotics there was a family history of tuberculosis (Jolly), and that chlorotics were prone to become tuberculous (Landouzy and Marcel Labbé), which, perhaps, was another aspect of the warning, formerly so hackneyed, not to regard as chlorosis what was really the early stage of pulmonary tuberculosis.

In 1872 Virchow attempted to show that in many if not all of those who became chlorotic at puberty there was in addition to deficiency of blood a congenital hypoplasia of the heart and blood-vessels, especially of the aorta; this was partly explained by concomitant mitral or aortic disease (Hilton Fagge). An intestinal origin was put forward by Sir Andrew Clark (1826-93) in 1887 to the effect that it was due to toxic absorption as the result of constipation, and by G. Bunge who argued in the same year that as the result of intestinal disorder sulphuretted hydrogen was formed and fixed iron in the intestinal contents, so that it could not be absorbed. Both these hypotheses were contested by R. Stockman in 1893.

That there is not a great reduction in the number of the reds but in the quantity of the hæmoglobin was first pointed out by Johann Duncan in 1867; an account of the blood changes was given in 1889 by Hayem, namely a diminution in the amount of hæmoglobin with or without a fall in the red count. This held the field until a very different condition was revealed in 1900 by Lorrain Smith (1862-1931); using the carbon monoxide method of determining the total amount of blood in the circulation and the total quantity of hæmoglobin contained, devised in conjunction with J. S. Haldane, he showed that the blood change is a great dilution of the plasma—hydræmic plethora—without any real diminution in the hæmoglobin content, and with a greatly increased amount of both red and white corpuscles.

Chlorosis is a striking example of the change of type of disease; formerly so extremely common as to be a drug in the out-patient department, it has now become a treasured rarity; in fact it is almost extinct. Several hypotheses for this have been proposed, such as better hygienic conditions in regard to food, exercise, fresh air, and the disappearance of the corset. But the general opinion is that the cause of this change is unknown. Since it began to disappear, a microcytic hypochromic

form of anæmia mainly in middle-aged women with achlorhydria and curable by iron—simple achlorhydric anæmia (Witts, 1930)—has been described, first by Knud Faber in 1913. Although Meulengracht (1923) called it "chronic chlorosis" it differs from chlorosis, in which there is commonly hyperchlorhydria, and resembles Addisonian anæmia in being associated with achlorhydria and in its familial character. The allied syndrome of anæmia and dysphagia was described in 1919 by Brown Kelly and by Paterson, by Vinson in 1922, and is usually known as the Plummer-Vinson syndrome.

Blaud's pill: P. Blaud (1774-1858), médecin-en-chef de l'hôpital de Beaucaire in Paris presented a paper to the Académie Royale de Médecine on August 23, 1831, dealing with chlorosis and its specific treatment. This paper gives the formula of the pill, composed of sulphate of iron and carbonate of potassium, which bears his name; he said that iron had always been given for chlorosis,<sup>1</sup> doubts about its specificity being due to the small doses given and the form in which it was administered. In 1838 after a committee appointed by the Académie Royale de Médecine had adversely reported on his anti-chlorotic treatment, Blaud returned to the charge with records of fifty cases successfully treated.

*Nutritional anæmia*, especially in infancy and due to lack of iron (Mackay), has recently been increasingly recognized.

*Addisonian anæmia*.—Synonyms: Idiopathic, pernicious, anæmia. Cases probably of this nature were reported by J. S. Combe (1796-1883) of Edinburgh in 1823, Andral of Paris in 1823, Marshall Hall (1790-1857) of London in 1837, Piorry (1794-1879) of Paris in 1840, and Channing of Boston, Mass., in 1842, before Thomas Addison (1793-1860) first in his paper on March 15, 1849, before the South London Medical Society "On Anæmia—Disease of the Suprarenal Capsules," and in his more accessible monograph *On the Constitutional and Local Effects of Disease of the Suprarenal Capsules* in 1855, described "idiopathic anæmia." According to Stephen Mackenzie (1844-1909) Addison had distinguished "idiopathic" from other forms of anæmia in his lectures at Guy's Hospital as early as 1843. In 1855 Samuel Wilks (1824-1911), Addison's loyal colleague, examined the blood in a number of cases and found that there was not any increase in the number of white corpuscles, and in 1857 confirmed Addison's observation, in one case, of fatty change in the myocardium, from the experience of seven necropsies. In 1872 Anton Biermer (1827-92) of Zürich described fifteen cases of "progressive pernicious anæmia," mentioning fever, which Addison had not done; this was regarded on the Continent as a new disease and often called "Biermer's anæmia"; this perhaps was a not unnatural result of Addison's account being included in his monograph on suprarenal disease. Accordingly P. H. Pye-Smith (1840-1914) in 1875 drew the attention of German readers to Addison's account, by an article on "idiopathic pernicious anæmia" in *Virchows Archiv*, and in 1883 collected 102 cases of the "idiopathic anæmia of Addison, since called essential, pernicious, or progressive anæmia." Although Biermer included various forms of grave anæmia, Hiltén Fagge (1838-83) in his textbook (1886) preferred the adjective "pernicious" to the somewhat vague epithet "idiopathic." In 1909 William Hunter, following Pye-Smith's example, suggested the eponym "Addison's Anæmia," which is now doubly appropriate, as the treatment by liver and stomach preparations has obviated the pernicious character of the disease and rendered that adjective obsolete.

In 1860 Austin Flint (1812-86), and in 1877 Samuel Fenwick (1821-1902), ascribed the disease to atrophy of the gastric glands. S. O. Habershon (1825-89), in 1863 considered that the nerves of the stomach were responsible. After this the disease was often confused with and diagnosed in what turned out to be gastric carcinoma. Wilkinson in 1933 pointed out the rarity of the association of malignant disease with a true Addisonian anæmia, having collected 35 cases only. The anæmia

<sup>1</sup> According to Garrison iron was given in the fifteenth century by Baverius de Baveriis (obit 1480).

of malignant disease is usually microcytic or hypochromic rather than megaloblastic as in Addisonian anæmia. From 1888 William Hunter's view of Addisonian anæmia as a hæmolytic result of streptococcal infection practically superseded Fenwick's explanation, until the recent demonstration that the primary cause is failure of the stomach to supply the substance which looks after the formation of the corpuscles in the bone-marrow, in fact a deficiency disease. It may be mentioned here that the sore tongue, which A. W. Barclay (1817-84) had reported in 1851, did not receive general recognition until William Hunter in 1889 insisted on its clinical significance.

Except for Wilks' examination of the leucocytes in 1855, the first published account of the microscopical characters of the blood has been stated to be that of Leared in 1858; in a girl, aged 11 years, who had frequent vomiting and died emaciated, the blood discs were described as very variable in size; that it was a grave anæmia for which a cause was not found is obvious, but that it was Addisonian anæmia can hardly be accepted. Neumann in 1868 reported changes in the red bone-marrow and spleen. Important microscopical observations were published in 1876; Cohnheim described the hyperplastic state of the red bone-marrow and the presence in it of large nucleated red cells. H. Quincke (1842-1922) discovered the excess of iron in the viscera, and insisted on the irregular size of the red cells in the circulation; and H. E. Eichhorst (1849-1921) laid stress on the presence of microcytes in the blood. This anisocytosis has been developed into the important "curve" of the diameter of the red cells, which is so characteristic of Addisonian anæmia, by C. Price-Jones, who ascribes the earliest construction of red-cell diameter "curves" to L. Malassez in 1889. In 1876 Sørensen showed that megalocytes were characteristic of the disease, but the method of measurement was, for a time, abandoned for the less laborious determination of the colour-index which Laache pointed out in 1883. In November 1877, Byrom Bramwell (1847-1931) described the blood picture—absence of rouleaux formation, poikilocytosis, and nucleated red cells, thus confirming some of the observations made earlier in the same year by Mackern and Davy at Guy's Hospital. In 1880 Ehrlich laid down as characteristic of the disease nucleated reds, especially megaloblasts, polychromatophilic ("anæmic") degeneration of the red cells, and leucopenia previously pointed out by Eichhorst in 1878. Ehrlich in 1886 also distinguished the condition of aplastic anæmia. Amœboid movements in the megaloblasts, like those in the polymorphonuclear leucocytes, were described by W. S. Thayer (1863-1932) in 1911.

Achlorhydria was pointed out in 1886 by Cahn and von Mering; in 1898 Knud Faber observed it in a case in which the symptoms of subacute combined degeneration preceded the onset of anæmia, and in 1922 Hurst and Bell showed the constancy of achlorhydria in subacute combined degeneration. The hereditary nature of achlorhydria and so of Addisonian anæmia dates from 1918 (Weinberg).

Subacute combined degeneration of the spinal cord was first described by Leichtenstern (1845-1900) in 1884 as progressive pernicious anæmia in tabetic patients. Gowers (1845-1915), however, gave a description in 1886 of ataxic paraplegia, but without any reference to the association with severe anæmia. The importance of anæmia was restored by Lichtheim (1845-1915) in 1887, H. M. Bowman (1866-96) in 1894 and others, and confirmed by Risien Russell, Batten, and Collier in 1900. The retinal hæmorrhages were first described by Biermer in 1872, and were observed independently in 1877 by Byrom Bramwell.

Treatment: Various methods have been adopted; blood transfusion was extensively employed during this century, after the recognition of blood groups rendered this old form of treatment less prone to be followed by severe reactions; but though some (Keynes, 1922; Hurst, 1924) regarded it of great value, others considered that its effect was transitory. Bone-marrow by the mouth was advocated by T. R. Fraser (1841-1920) in 1894, and excision of the spleen had a brief vogue. Arsenic had been recommended by Clermont in 1868, and by F. E. Anstie (1833-74) as a blood

tonic, but the credit for its use in pernicious anæmia is due to Byrom Bramwell (1847-1931), then physician and pathologist at the Newcastle-on-Tyne Infirmary, who, in November 1877, recommended its administration which he had begun two years before; this long remained the sheet anchor in treatment; in 1911 he reported the use of salvarsan. Hydrochloric acid had been prescribed by Quinke in 1876, but, about 1921, Hurst began the administration of large doses. The researches of G. H. Whipple in 1925 led to the establishment of the treatment by liver by G. R. Minot and W. P. Murphy in 1926, and later, after the observations of Castle (1929) by preparations of stomach, which provide the anti-anæmic, heat-labile substance or enzyme "hæmopoietin" that by interaction with protein food forms the relatively heat-stabile, anti-anæmic principle stored in the liver (Sturgis and Isaacs, 1929; Wilkinson, 1932, 1933).

*Agranulocytic angina, agranulocytosis, malignant neutropenia.*—In 1902 P. K. Brown recorded a fatal case of acute primary infectious pharyngitis with extreme leucopenia; but this condition did not attract any attention until in 1922 Schultz gave an account of it as agranulocytosis and occurring in middle-aged women. It is usually, but not always, associated with ulcerative or gangrenous lesions of the mouth and pharynx, and Friedemann called it agranulocytic angina. The leucoblastic bone-marrow shows an almost complete absence of the myeloid series, and the blood shows a reduction of the granular cells, the erythrocytes being but little affected. The mortality, usually from some infection, such as pneumonia, is high.

*Splenic anæmia.*—After the description of leukaemia in 1845 and of pseudo-leukaemia by Cohnheim in 1865, the term splenic anæmia was introduced by Gretscl in 1866 in reporting the case of a child in the clinic of W. Griesinger (1817-68) in Berlin; this case belonged to the group of infantile splenic anæmia. In America H. C. Wood (1841-1920) of Philadelphia in 1871 was the first to write on the subject in a paper on "the relations of leucocythæmia and pseudo-leukaemia." Guido Banti (1852-1925) of Florence in 1882 described the morbid changes in the spleen, and in 1894 gave an account of hepatic cirrhosis as the sequel of the earlier stage of splenic anæmia; the term "Banti's syndrome" should be restricted to this sequel and not used as a synonym for chronic splenic anæmia. In 1891 I. Bruhl, a pupil of G. M. Debove (1845-1920) who invented the title "splénomégalie primitive," described a group of cases of comparatively short duration, of six months to two years, and primary in the spleen. Samuel West (1848-1920) in 1896 and 1898 wrote on much the same lines. A much more definite clinical picture was presented by Osler (1849-1919) in two papers (1900, 1902) which brought the subject of chronic splenic anæmia of adults prominently before English-speaking medical men; he defined it as a chronic splenomegaly of unknown origin, with the chlorotic type of anæmia, a normal or leucopenic white count, and a liability to recurrent gastro-intestinal hæmorrhages. As the syndrome of splenomegaly with anæmia was progressively shown to be due to various underlying factors, such as syphilis, tuberculosis, subacute bacterial endocarditis, Gaucher's disease, and chronic thrombophlebitis of the splenic vein, the category of chronic splenic anæmia became a residual receptacle for cases of undetermined origin. Treatment by splenectomy was introduced by Banti.

*Infantile splenic anæmia.*—In 1884 Somma reported cases under this title, and in 1889 R. von Jaksch published others of "anæmia pseudoleukæmica infantum" with splenomegaly, anæmia, and persistent leucocytosis. It was also described in 1891 by Luzet. Infantile splenic anæmia has been much discussed, and probably several different diseases have been described under this heading, such as various secondary anæmias. Cooley in 1927 isolated erythroblastic anæmia which shows nucleated reds in the blood and presents some resemblances to congenital hæmolytic jaundice and sickle-celled anæmia.

*Gaucher's and Niemann's diseases.*—In 1882, C. P. E. Gaucher (1855-1918), in his Paris thesis, described the splenic enlargement as a new growth (épithéliome

primitif de la rate). The next case actually recorded was in 1895 by W. Collier; it was recognized, after Picou and Ramond in 1896 described the histological appearances in the third case, as the same as the other two. In 1900 Bovaird showed that the change was endothelial proliferation and not a neoplasm. In 1905 Brill, Mandlebaum, and Libman pointed out that the large "Gaucher cells" occur in the bone-marrow; Mandlebaum, of the Mount Sinai Hospital, New York, collected and established the morbid changes. Pick in 1922 thoroughly described the bony lesions, and in 1926 Junghagen established the value of radiological examination of the skeleton. The blood shows anæmia and leucopenia, probably as the result of the changes in the bone-marrow, thus differing from the anæmia with leucocytosis in Niemann's disease. Until at least this century cases of Gaucher's disease were included under the heading of splenic anæmia.

Niemann in 1914 described an "unknown disease" occurring in infancy and running a rapidly fatal course before the age of two years, thus contrasting with the chronicity of Gaucher's disease. L. Pick described it fully in 1926, and it has been called Niemann-Pick's disease. It is more frequent in Jews than is Gaucher's disease, and resembles Gaucher's disease in being familial and an infiltration of the cells of the reticulo-endothelial system but with a chemically different material. The disease is also connected with amaurotic family idiocy, and it has reasonably been regarded as a form of xanthomatosis, a disorder of lipid metabolism (Rowland), other members of this series being amaurotic family idiocy, the Hand-Schüller-Christian syndrome, Gaucher's disease, and other manifestations, such as those in the skin, of xanthomatosis.

*Erythræmia.*—Synonyms: Polycythæmia vera, Vaquez-Osler disease. In 1892 H. Vaquez described a special form of cyanosis accompanied by excessive and persistent polycythæmia, and in 1895 reported that the necropsy of this patient showed splenomegaly without any cardiac lesion. Osler's papers on "Chronic cyanosis with polycythæmia and enlarged spleen" in 1903, and on "Chronic cyanotic polycythæmia with enlarged spleen: a new clinical entity" in 1904 really made the condition known in America and England. A complete necropsy was published in 1904 by Parkes Weber and Watson, and a most comprehensive monograph on the subject was brought out by Weber in 1921 with a supplement in 1929. The condition had previously been included under plethora; but in 1843 Andral had found that the red cells were increased in number and the water diminished; he also pointed out that the same symptoms—dizziness, vertigo, and tinnitus aurium—may be produced by an excessive number and by a diminished number of corpuscles in the vessels; this was independently described by Christian in 1925. Hughes Bennett in 1863 spoke of an increased red count as "polypyrænæmia" (πύρην = nucleus). Weber refers to Cuffer and Sollier's description in 1889 of the "congestive venous diathesis" as perhaps drawn from cases of erythræmia. As cyanosis may be absent (Christian) the original titles have rightly been superseded.

It has been regarded as analogous to leukæmia but of a more benign character (Weber, 1908), as a myeloma or innocent tumour of the red bone-marrow (Ribbert, 1904; Weber). A hormonal factor was suggested by Hirschfeld as controlling the formation and destruction of the red cells, and Morris, Schiff, and Foulger (1932) regard it as the converse of pernicious anæmia and due to an excess of the body which, formed by the stomach, is essential for the maturation of the red cells; this they call "Addisin" and consider to be probably a hormone.

The hereditary and familial character was first recorded by Bernstein in 1914, and has since been widely confirmed, for example by Engelking (1920), Curschmann (1922), Doll and Rothschild (1922), and Spodara and Forkner (1933) who recorded a family of six in which five had benign erythræmia, two of them also having Huntington's chorea.

As in the case of leukæmia, it was many years before the condition was recognized in children; since 1920, however, a number of cases, often without prominent symptoms but with a familial incidence, have been reported, especially in Central Europe (Engelking, 1920; Wieland, 1924; Hottinger, 1927).

Among the complications, or perhaps it would be better to call them variations, of erythræmia are the combination with high blood-pressure (polycythæmia hypertonica) described in 1905 by Gaisböck, and the combination with leukæmia or erythro-leukæmia—a pan-myelosis—described in 1905 by Blumenthal and sometimes called Blumenthal's disease.

*Leukæmia.*—Synonym: Leucocythæmia. It is difficult to say when cases of what may have been of this nature were first reported; Virchow (1821-1902) in his account of "white blood" in 1845 referred to records of blood resembling milk, for example by Albrecht von Haller (1708-77) in 1760; but these may have been due to lipæmia. Velpeau (1795-1867) in 1827 recorded a case with splenic enlargement and a naked-eye change in the blood, like the lees of wine, but a microscopical examination was not made. In 1839 Barth (1806-77) had a case in the Hôtel-Dieu, Paris, and at the necropsy in July of that year Alexandre Donné found that half the blood cells were "mucous" (white) corpuscles; but this observation was not published until 1856 and then by Vidal (1825-93).

The first descriptions of microscopical examination of the blood were published almost simultaneously in the autumn of 1845 in Edinburgh and Germany, and thus a barren problem of priority arose. On October 1, 1845, two cases were reported under the heading of "Disease and Enlargement of the Spleen in which Death took place from the Presence of purulent matter in the Blood"; the first case was put on record by David Craigie who had been a lecturer on medicine in the extramural school at Edinburgh since 1834; the patient had been under his care in 1841 when John Reid (1809-49), then pathologist to the Royal Infirmary, and in that year elected Chandos Professor of Medicine at St. Andrews, examined the blood obtained at the necropsy and briefly reported that "it contained globules of purulent matter." Craigie explained that he now published the case "chiefly because the occurrence of the case, in many if not in all respects, similar to that of another physician in the same hospital, led me to anticipate similar results, and went far to confirm my conclusions deduced from the first case." After Craigie's death Hughes Bennett, in 1854, stated that the significance of the blood changes was not appreciated or indeed remembered until they were found in the second case, and that Craigie did not use the microscope. The second case of "Hypertrophy of the Spleen and Liver in which Death took place from Suppuration of the Blood" was under the care of Sir Robert Christison (1797-1882), but was reported by John Hughes Bennett who performed the necropsy, gave a much fuller account of the blood picture than Reid had done, and illustrated his article with blood-films. He regarded it as due to pyæmia. Six weeks later, in November 1845, Virchow independently published a case of "white blood" also examined after death, and from microscopical examination of the blood stated that the appearances were quite different from those in pyæmia: he used the word "leukæmia" in 1847. In a paper read before the Société de biologie in Paris in April, 1851, Hughes Bennett recorded four cases he had examined, collected eight others reported, and objected to the name "leukæmia" on the ground that the blood was not white, and contended that leucocythemia (as he first spelt it in English) (λευκός = white, κύθος = cell, and αἷμα = blood), "white-cell blood," more correctly described the condition; he then gave up the description of suppuration of the blood. In the following year he brought out an expanded monograph with references to 27 cases. As regards priority, Craigie's case was the first, but apparently it would not have been published had not Hughes Bennett worked up another; Leudet in 1855 gave the priority to Virchow who said it did not belong either to himself or to Hughes Bennett. In October 1854, Kölliker (1817-1905) took up the cudgels for Virchow

and Hughes Bennett replied with vigorous alacrity; in 1863 the latter returned to the subject and spoke of the "leucocyths after Robin."

In 1846 the examination of the blood attracted further attention; on June 23 H. W. Fuller (1820-73) described the microscopical changes which he had found in the blood on several occasions during life as well as after death in a patient under Dr. R. Nairne (1804-86), and stated that the disease was not primary in the spleen but constitutional.

Fuller made this communication before the Royal Medical and Chirurgical Society, of which W. F. Chambers (1786-1855), his senior at St. George's Hospital, was president, so it would seem probable that Fuller's demonstration was arranged in relation to a paper, communicated by Thomas Hodgkin (1798-1866), at that meeting by J. B. S. Jackson (1806-79) of Boston, Mass., on "A peculiar derangement of the spleen," in which it was argued, as Rokitsky had done, that the white areas in the spleen of lymphadenoma were infarcts. In March 1847 T. K. Chambers (1819-89) described in the blood of a case of big spleen "a large number of granular, irregular, spheroidal bodies two or three times the size of blood corpuscles"; these were evidently myelocytes.

In August 1846 W. H. Walshe (1812-92) demonstrated to his pupils at University College Hospital the blood with equal numbers of coloured and of colourless corpuscles. Virchow in 1847 described two forms, splenic and lymphatic, in which the white cells were said to be manufactured in the enlarged spleen (splenæmia, larger cells) and in the enlarged lymphatic glands (lymphæmia, smaller cells).

Cohnheim in 1865 introduced the term "pseudo-leukæmia" for cases in which the lymphatic glands showed the histological picture of leukæmia without the corresponding blood changes, or what would now be called an aleukæmic phase of leukæmia or aleukæmic lymphadenosis. This name was applied by some to lymphadenoma, thus creating unfortunate confusion. Magnus Huss (1807-90) suggested that a distinction should be drawn between leucocytosis and leukæmia when the white corpuscles reached the number of one to twenty red cells. This quantitative was changed into a qualitative distinction by Ehrlich's classification of the white cells. Neumann in 1870 pointed out the changes in the bone-marrow which led to the recognition of the myelogenous form, but that this was slowly adopted is shown by the title "Splenic leucocythæmia" of the full article in 1879 in Russell Reynolds' *System of Medicine* by W. R. Gowers. In 1888 W. Hunter, while recognizing a relation between the blood changes and those in the spleen, lymphatic glands, and bone-marrow, regarded leucocythæmia as "a special form of idiopathic anæmia." In 1878 Neumann observed that the amœboid movement in the polymorphonuclears was very sluggish; John Cavafy (1837-1901) in the same year described the paucity of white cells showing amœboid movement. Ehrlich, in 1880, pointed out the occurrence of normoblasts in the blood.

There was a long delay in the recognition of the disease in childhood; it was recorded by Biermer in 1861 and F. V. Birch-Hirschfeld (1842-99) in 1878. An acute case was reported in 1857 by Friedreich (1825-82), in 1889 Ebstein (1836-1912) gave an account of the clinical features, and in 1895 A. Fraenkel described the character of the cells. The importance of myeloblasts was pointed out by Naegeli in 1900, and various cellular forms of leukæmia have subsequently been described, for example, the rarely recognized acute monocytic (Reschad and Schilling-Torgau, 1913), which is specially associated with destructive lesions in the mouth. Charcot (1825-93) and Robin in 1853 described the crystals obtained from the blood and organs after death, and in 1860 Charcot and Vulpian again gave an account of them. The raised basal metabolic rate was described in 1911 by Grafe. X-ray therapy was first reported in 1903 by Nicholas Senn (1844-1909), the case being treated by W. A. Pusey; Senn believed that leukæmia was due to "microbes" and that irradiation destroyed them. Dock, in the following year, fully reviewed this treatment on the basis of twenty-nine reports. Stengel and Pancoast, in 1907, advocated a "new and more rational method."

*Chloroma* was described long before leukæmia was recognized. In 1811—not in 1823, as sometimes stated—Allan Burns (1781-1813), surgeon and anatomist at Glasgow, first gave a brief account of a case, and in 1835 Balfour (1808-84), of Edinburgh, recorded another case with a coloured plate of green tumours on the dura mater. In 1853 King, also of Edinburgh, published a paper on a case observed in 1849 under the heading "*chloroma*" as if it was in common use, though that word does not occur in the text of his article; there is not, as Dock has shown, any evidence of its previous use, so it would appear that King invented it and perhaps employed it as a *ballon d'essai*. In 1854 Aran (1817-61) of Paris recorded a case seen in 1851, referred to King's paper and translated "*chloroma*" into *cancer vert*. The relations of *chloroma* and leukæmia were recognized by Huber in 1878 and more fully by von Recklinghausen (1833-1910) in 1885. The history of *chloroma* was analysed in 1893 by Dock, who independently had grasped the identity of *chloroma* and leukæmia, and in 1904 brought the number of recorded cases up to thirty-eight. In reporting four cases of acute myelocytic *chloroma* in 1924 Goodall and Alexander estimated that eighty cases had been published.

*Leukanæmia* was described in 1903, by von Leube, as a condition showing a blood picture of combined leukæmia and Addisonian anæmia. In 1903 Luce and in 1904 Parkes Weber recorded cases, and in 1907 J. H. Drysdale analysed the recorded cases and concluded that they were atypical myelocytic leukæmia and that the term "*leukanæmia*" might well be abandoned.

*Hæmophilia*.—Nomenclature. The derivation from *αἷμα* = blood and *φιλία* = love, is obvious; but De Fleury in 1866 derived it from *φύλη* = a race or tribe, and this would emphasize its hereditary nature while necessitating a different spelling. Virchow ascribed the invention of the word *hæmophilia* to J. L. Schönlein (1793-1864), but Wickham Legg (1843-1921) doubted this and referred to Hopf's inaugural dissertation with this title in 1828 at Würzburg, rather sternly adding "the word is so barbarous and senseless that it is not wonderful that no one is proud of it." The term "*bleeder*" was first employed in print by Otto, who said that it was used in the families affected.

According to Wickham Legg, there does not appear to be any case recorded in classical Greek or Latin literature. But the Talmud, dating from the return from the Babylonian captivity in 536 B.C., forbade circumcision in a family after two successive children had died as a result—thus suggesting a bleeder family. Albucasis (1030-1106) described the condition, and cases were reported by Philip Höchstetter (*ob.* 1635), of Augsburg, in a work published by his son in 1674, and by Henry Banyer of Wisbech in 1743. Bulloch and Fildes, who in 1911 critically analysed 911 cases, regarded as doubtful the early examples reported by Alexander Benedictus (1539), Samuel du Gard (1674), Ash (1686), Clopton Havers (1695), W. Musgrave (1702), and William Fordyce (1784).

In 1803 John Conrad Otto (1774-1844) of Philadelphia gave the first clear "Account of an hæmorrhagic Disposition existing in certain Families," and stated that males only are affected, and that females are not affected but are capable of transmitting it. This was emphasized in 1820 by C. F. Nasse (1778-1851) and is known as Nasse's law. In 1813 John Hay of Reading, near Boston, Massachusetts, published the history of the Appleton-Swain family, which was brought up to date by Osler in 1885, and J. H. Pratt in 1908, with its pedigree for more than two hundred years. Its occurrence in Royal families in Europe has provided great opportunities for tracing its transmission.

Many cases in females have been reported, for example 48 in Grandidier's collection in 1855, but their occurrence can now be explained by the existence of another hereditary hæmorrhagic diathesis, described by Hess in 1916 as an hereditary form of purpura hæmorrhagica which Glanzmann in 1918 called hereditary hæmorrhagic thrombasthenia; it occurs in both sexes, but more often in females, and has

been said, though not without contradiction, to be due to essential thrombocytopenia. Another condition which has been confused with hæmophilia and may occur in females, is that of multiple hereditary telangiectases with recurrent hæmorrhages, described by Osler in 1901, and by Parkes Weber in 1907; Hurst and Plummer in 1932 added 7 to the previously reported 49 families and believed it to be more frequent than is usually considered.

The well-marked fertility of bleeder families was pointed out in 1849 by Wachsmuth and was well shown in the Mampel stock recorded by Lossen in 1905.

*Purpura* may be due to many causes, and accordingly various forms have been classified under different headings; for example, it may be due to bacteria and poisons damaging the vascular endothelium and walls, as in septicæmia and toxæmia. Reference here, however, will be confined to the following forms of historical interest.

P. C. Werlhof (1699-1767) in 1735 described as "morbus maculosus hæmorrhagicus," the disease which has since received other names, such as the eponym Werlhof's disease, purpura hæmorrhagica, thrombocytolytic purpura (Kaznelson, 1919), essential thrombopenia (E. Frank, 1925). In 1916 Hess described a hereditary form, and in 1918 Glanzmann employed the term hereditary hæmorrhagic thrombasthenia for these cases. Great diminution in the number of the platelets was pointed out by Bröhm in 1881, independently by J. Denys in 1887, and in 1890 by Hayem who made platelet counts. This blood change has been regarded in various lights; it has been thought to be the primary cause of the purpura and due either to their deficient formation, as the result of an inhibitory toxin, by the bone-marrow (Frank), or to their destruction by the reticulo-endothelial cells, especially in the spleen (Kaznelson). On the other hand, it has been argued that the diminution of platelets in the peripheral circulation is not the cause but the result of hæmorrhage, the platelets being withdrawn from the circulation and fixed in the bleeding areas as a defence mechanism (Tidy, 1926). Splenectomy was recommended by Kaznelson in 1919.

Anaphylactic purpura: Under this recently introduced heading two previously described forms have now been combined. These are (a) peliosis rheumatica, or arthritic or rheumatic purpura, described in 1837 by J. L. Schönlein, and (b) the form of purpura with abdominal symptoms described in 1874 by E. H. Hensch (1820-1910), Schönlein's former pupil, and often called "Hensch's purpura." It may be included as a member of the more extensive group of erythema exudativum with visceral symptoms described by Osler in 1900, and shows resemblances to angioneurotic oedema described by J. L. Milton (1820- ) as giant urticaria in 1876, by H. N. Bannister in 1880, and by H. Quinke of Kiel in 1882.

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## Section of Otology

President—W. J. HARRISON, M.B.

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### The Otosclerosis Problem: including Reports of Two Cases Pathologically Examined

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*Dalby Memorial Lecture.*

**ABSTRACT.**—The essential causative factor of otosclerosis is a gradually increasing defect in the vasomotor mechanism which governs the nutrition of the structures of the organ of hearing as a whole. The axon reflexes are, of course, included in this vasomotor mechanism, and the stimulus which excites the vasomotor mechanism is sound and sound alone. Consequently the vestibular apparatus and the semicircular canals are unaffected in otosclerosis.

There is no evidence whatever of any defect in any of the endocrine glands or their secretions in otosclerosis. Neither is there any evidence of any defect in the bone metabolism of the body. On the contrary the subjects of otosclerosis are, apart from their deafness, perfectly normal individuals with ordinary average health.

The deafness of otosclerosis bears very little relationship to the extent of the disease in the bone. The deafness may be very severe when the stapes is hardly fixed at all.

The severity of the tinnitus bears no relationship at all to the extent of the disease in the bone.

The extent of the change in the bone bears very little relationship to the duration of the disease.

The extent of the changes in the bone appears to depend upon the age of onset of the disease. The earlier in life that the otosclerosis begins, the more extensive will the bone lesion become.

The deafness of otosclerosis is to a large extent functional, and is the result of the insufficient supply of blood to all the nerve-structures concerned in the perception of sound.

The preponderance of women as subjects of otosclerosis is the result of the greater instability of their vasomotor system and the more frequent disturbances to which it is exposed.

The changes in the bone show a remarkable bilateral symmetry even to minute details. This symmetrical distribution is readily explained by the writer's view of the causative factor of otosclerosis. The vasomotor nerves governing the nutrition of the organ of hearing are anatomically symmetrical like other nerve-structures in the body. If, therefore, structural changes occur as a result of defective functioning of those nerves, such structural changes will naturally be bilaterally symmetrical in their distribution.

**RÉSUMÉ.**—Le facteur étiologique essentiel de l'otosclérose est un défaut graduellement progressif de l'appareil vasomoteur nourrissant l'organe auditif entier. Les réflexes cylindraxiles sont inclus dans ce système vasomoteur, et le stimulus qui excite le système vasomoteur est uniquement le son. Par conséquent l'appareil vestibulaire et les canaux semicirculaires ne sont pas attaqués dans l'otosclérose.

Il n'y a aucune évidence qu'il existe un défaut quelconque des glandes endocrines ou de leurs sécrétions. Il n'y a non plus de défaut du métabolisme osseux. Au contraire, les otosclérotiques, à part leur surdité, sont parfaitement normaux, et jouissent d'une santé normale.

La surdité de l'otosclérose a très peu de rapport avec l'étendue de la maladie des os. Elle peut être très considérable quand l'étrier est à peine fixé.

La gravité du tinnitus n'a aucun rapport avec l'étendue de la maladie des os.

Le degré d'altération des os a très peu de rapport avec la durée de la maladie.

L'étendue de la maladie de l'os dépend de l'âge du malade au commencement de la maladie. Plus la maladie commence tôt, plus la lésion osseuse deviendra étendue.

La surdité otosclérotique est en grande partie fonctionnelle, et résulte de la provision défective de sang aux structures nerveuses qui s'occupent de la perception du son.

La prépondérance des femmes parmi les otosclérotiques est une conséquence de la plus grande instabilité de leur système vasomoteur et des perturbations plus fréquentes auxquelles il est exposé.

Les lésions osseuses sont remarquablement symétriques, jusqu'aux plus petits détails. Pour l'auteur cette symétrie s'explique aisément par sa théorie de l'étiologie de l'otosclérose. Comme les autres structures nerveuses, le système vasomoteur gouvernant la nutrition de l'organe auditif est anatomiquement symétrique. Par conséquent, si des altérations structurelles surviennent comme résultat du fonctionnement défectif de ces nerfs, elles seront naturellement symétriquement distribuées.

**ZUSAMMENFASSUNG:** Das wesentliche ätiologische Moment der Otosklerose ist ein allmählich progressiver Defekt in dem vasomotorischen Mechanismus welches die Ernährung der Strukturen des Gehörorgans beherrscht. Die Axonreflexe sind natürlich in diesem vasomotorischen System eingeschlossen, und der einzige Stimulus der das vasomotorische System reizt ist der Schall. Das vestibuläre System und die Bogengänge sind somit in der Otosklerose nicht beteiligt.

Es gibt kein Beweis dass ein Fehler in den Blutdrüsen oder in ihren Sekretionen besteht. Es gibt auch kein Fehler in dem Knochenstoffwechsel. Im Gegenteil sind die Otosklerotiker von ihrer Taubheit abgesehen, vollständig normale Leute, und ihre Gesundheit ist normal.

Die otosklerotische Taubheit hängt sehr wenig von dem Grad der Knochenerkrankung ab. Es kann hochgradige Taubheit mit einem kaum fixierten Stapes bestehen.

Die Stärke des Tinnitus hängt gar nicht von dem Grad der Knochenerkrankung ab.

Der Grad der Knochenveränderung hat sehr wenig Beziehung zur Dauer der Erkrankung.

Der Grad der Knochenveränderungen scheint mit dem Alter am Beginn der Erkrankung zusammenzuhängen. Je früher die Otosklerose beginnt je schwerer wird die Knochenerkrankung.

Die Taubheit der Otosklerose ist weitgehend eine funktionelle, und ist durch die defektive Blutzufuhr an die in der Schallwahrnehmung beteiligten Nervenstrukturen bedingt.

Das Überwiegen der Frauen bei den Otosklerotikern ist bedingt durch die grössere Unbeständigkeit ihres vasomotorischen Systems und durch die häufigere Störungen an welche dieses ausgesetzt ist.

Die Knochenveränderungen zeigen eine bemerkenswerte Symmetrie, bis in die kleinsten Einzelheiten. Diese symmetrische Anordnung ist leicht durch die Theorie des Verfassers der Ätiologie der Otosklerose zu erklären. Wie die anderen Nervenstrukturen des Körpers sind die vasomotorische Nerven die die Ernährung des Gehörorgans beherrschen anatomisch symmetrisch. Wenn nun strukturelle Veränderungen auf defektive Funktion dieser Nerven folgt so werden diese Veränderungen auch symmetrisch verteilt sein.

IN the following pages the writer, after giving reports upon two cases of otosclerosis examined pathologically and one of them also clinically, intends to discuss the ætiology of the disease.

#### CASE I.

3.3.31: F. H., aged 27, admitted to Middlesex Hospital, March 3, 1931, suffering from Hodgkin's disease (see Hospital Report). At that date she was deaf in both ears, the right being the worse. Her deafness dates from the beginning of menstrual life at the age of 14. There is slight nystagmus. Patient is anæmic.

24.8.32: Patient readmitted August 24, 1932. She complained of inability to walk and felt giddy on sitting up. She was then very deaf and very anæmic.

13.9.32: Patient died September 13, 1932. Post-mortem examination twenty-four hours after death. Temporal bones fixed in Orth's solution (formalin 10%, Müller's fluid 90%).

*Examination of the Temporal Bones.*

The temporal bones were fixed in Orth's solution and decalcified in a watery solution of nitric acid.

**RIGHT EAR.**—To the naked eye the middle ear appears normal, and there is no fluid or pus present. The stapes appears to be fixed in the oval window.

Microscopic examination (fig. 1). There is a considerable thickening of the muco-periosteum of the middle ear in the neighbourhood of the footplate and crura of the stapes. The tensor tympani and stapedius muscles show no sign of degeneration. There is an area of newly formed spongy bone extending from a short distance in front of the oval window across the stapedio-vestibular articulation and along the footplate of the stapes to the posterior margin of the oval window. The

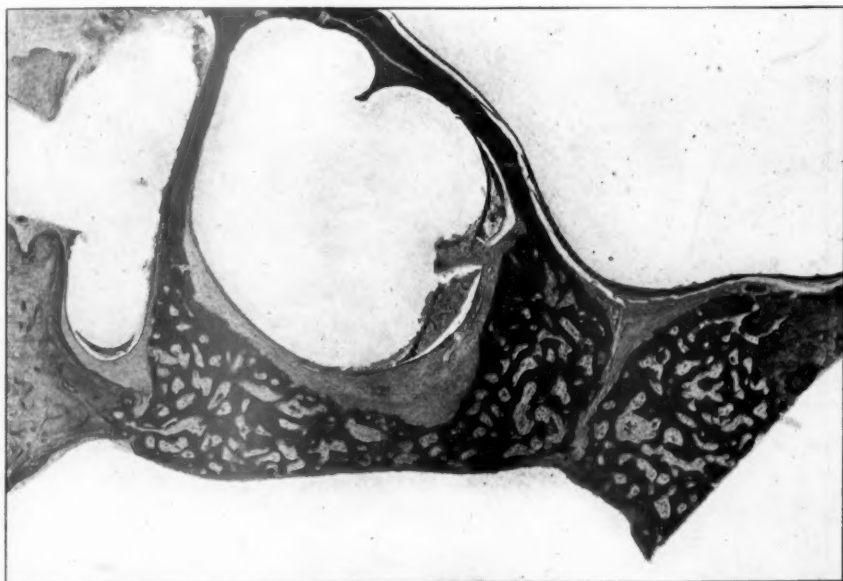


FIG. 1, Case I.—Right ear. The footplate of the stapes is seen fixed by bony tissue at the posterior extremity of the oval window. Fixation was also present at the anterior extremity but is not shown in this section. For description see text.  $\times 40$  circa.

stapes is thus fixed at both extremities of the oval window. The footplate of the stapes is very much thickened by the porous newly formed bone, and the latter extends for some distance up into both crura of the bonelet. The newly formed porous bone shows the usual characteristics of otosclerosis. It is defined from the normal bone of the capsule of the cochlea by a clear-cut line of demarcation. The large spaces in the newly formed bone contain marrow, and the bone tissue itself stains deeply with hæmatoxylin in marked contrast with the pale-staining normal bone surrounding it.

On the tympanic surface of the footplate of the stapes there appears to be going on a process of absorption of the newly formed spongy bone by the thickened

muco-periosteum described above. There is no round-cell infiltration in the thickened muco-periosteum or any dilatation of the blood-vessels, and the absorption of the bone appears to be carried out by the fibrous tissue of the muco-periosteum itself.

The vestibule and semicircular canals show no pathological changes. There is no effusion of blood or other exudate into these cavities.

The cochlea shows no evidence of disease. There is present the usual post-mortem disintegration which is always found in the human organ of Corti, but no pathological alteration is seen. The nerve-cells of the ganglion spirale are present in the usual number, and show a normal appearance. There is no alteration in the position of the membrane of Reissner, and the stria vascularis is quite normal.

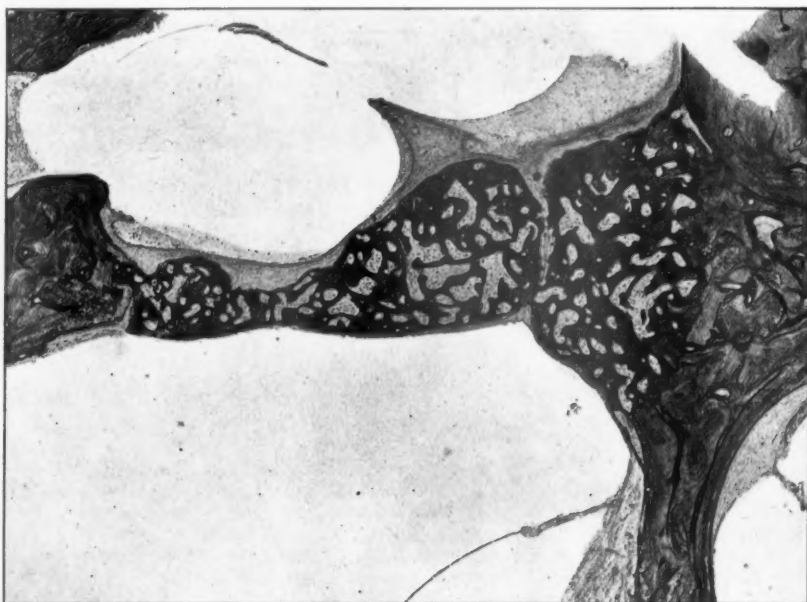


FIG. 2, Case I.—Left ear. The porous dark-stained newly-formed bone is shown clearly with its sharp line of demarcation anteriorly (to the right). Posteriorly the newly-formed bone has caused fixation at the posterior extremity of the oval window (to the left). The footplate is also fixed at its anterior extremity.  $\times 80$  circa.

**LEFT EAR (fig. 2).—**The left ear shows changes which are almost a replica of those found in the right. The muco-periosteum of the middle ear in the neighbourhood of the stapes is thickened, but is free from any round-cell infiltration or any sign of inflammatory activity. An area of newly formed porous bone is found extending from a short distance in front of the oval window through the stapedio-vestibular articulation, along the footplate of the stapes and for a very short distance behind the posterior margin of the stapedio-vestibular articulation. Hence the stapes is fixed in the oval window both in front and behind. The footplate is very much thickened by the newly formed bone, and the latter appears to be undergoing absorption to a certain extent by the thickened muco-periosteum lining its outer

surface. This process of absorption, however, has not occurred to such a great extent as on the right side. The vestibule and semicircular canals show no pathological change.

The cochlea appears to be normal, the disintegration seen in the organ of Corti being the result of post-mortem changes. The cells of the ganglion spirale have a healthy appearance, and show no sign of any diminution in number. The stria

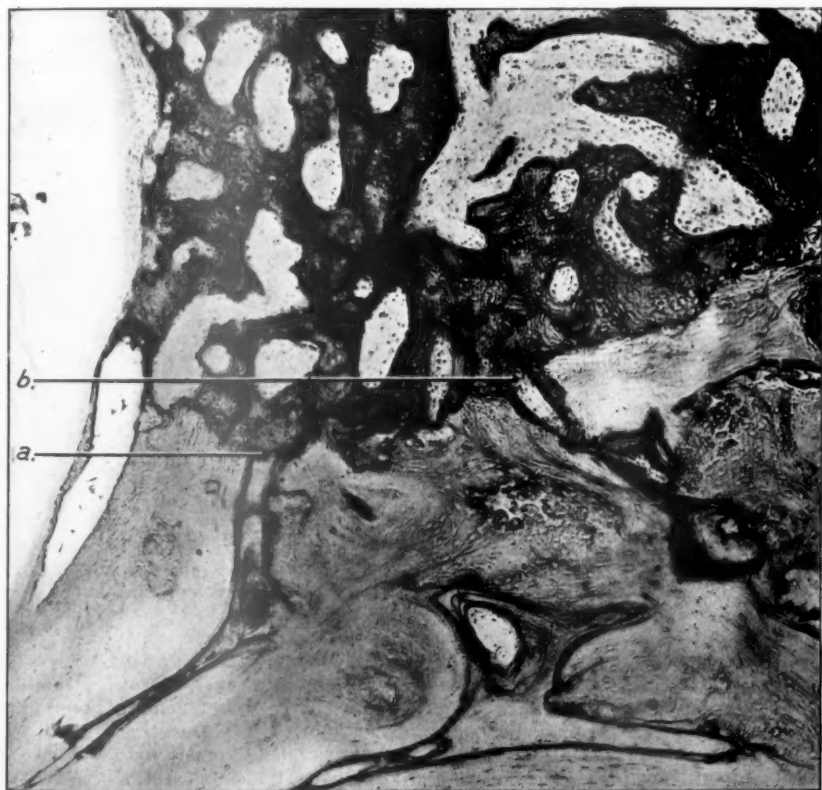


FIG. 3, Case I.—Left ear. Line of demarcation. The newly-formed dark-staining porous bone with large spaces filled with marrow is seen in the upper portion of the picture. Two dilated veins are seen, *a*, *b*, running from the normal bone (lower portion) to end abruptly at the line of demarcation. These veins appear to be the active agents in producing the change in the bone.  $\times 200$  circa.

vascularis shows no pathological change, and the membrane of Reissner is not depressed.

When the line of demarcation between the newly formed bone and the normal dense bone of the capsule is examined under a higher power (fig. 3), it is found that dilated veins run from the normal bone to the line of demarcation and there end abruptly. At these points the normal bone appears to be undergoing absorption round the ends of the walls of the veins.

## CASE II.

*Clinical Report.*

E. C., female, aged 41. Admitted to hospital, October 1932, suffering from carcinomatous glands in the supraclavicular region on both sides, secondary to a carcinoma of the breast which was removed in 1929.

Patient has been dull of hearing for 18 years. The onset was gradual and at no time has there been any pain, in or discharge from either ear. Tinnitus is constantly present and patient likens it to wind roaring. Paracusis is very strikingly noticed by patient, and her friends all observe that she hears quite well when in a train or 'bus or where there is considerable noise.

*Family history.*—One brother and one sister, besides the patient, are deaf out of a family of ten. Neither of these complained of tinnitus. Patient's father was deaf.

*Examination of the Ears.*

Both tympanic membranes are normal in appearance.

Right ear.	Left ear.
Watch. 1 in. (normal 5 in.).	Watch. 1 in.
Whisper. 1 ft.	Whisper. 2 ft.
Tuning-fork. All notes lost below la <sub>2</sub> .	All notes lost below sol <sub>2</sub> .
Bone-conduction. Rinne—25.	Rinne—20.
High notes. Very considerable loss.	High notes. Not lost so much as in right.
Galton's whistle. Mdh. 6-0, pfl. 5-87.	Galton's whistle. Mdh. 6-0, pfl. 5-02.

*Pathological Report.*

*Right ear.*—There is no perforation or scarring of the tympanic membrane and no sign of inflammatory activity, past or present, in the middle ear.

During the process of removing the cochlear nerve from the internal auditory meatus for separate examination, the bone unfortunately was fractured, the fracture running along the roof of the meatus and down to the oval window. Fortunately, however, the fracture did not to any important extent affect the subsequent microscopic examination.

*Right ear* (fig. 4).—On microscopic examination of the right ear an area of otosclerotic bone is found in front of the oval window and it presents the usual characters of the disease. It stains deeply with hæmatoxylin, is porous in texture with the spaces filled with marrow, and has a sharp line of demarcation. It is fairly large in area, the diameter being about two or three millimetres. Ankylosis of the stapedio-vestibular articulation is not present, but the newly formed bone has bulged outward over the articulation and thus caused locking at the joint. The footplate of the stapes itself is unaffected, but there is a small area of otosclerotic bone in the wall of the oval window at its posterior extremity. No ankylosis is found here.

On examining the line of demarcation under a somewhat higher magnification, points are found at which veins lying in the normal bone run towards the newly formed bone and there end abruptly at the line of demarcation and seem to be the factors in the formation of the new otosclerotic bone (fig. 5). It is interesting to observe that though islands of cartilage are present in the normal bone they appear to take no part in the formation of the new otosclerotic bone. The walls of the veins appear to be the active agents in this process and the islands of cartilage become absorbed when the new bone advances upon them, but there was no process of calcification of cartilage preliminary to absorption by bone corpuscles, such as occurs in the formation of bone in cartilage under normal circumstances.

The cochlea appears to be quite normal. The organ of Corti and stria vascularis show the effects of post-mortem maceration which is always present when the tissues are not fixed instantly after death, but no sign of pathological change is found. The ganglion spirale appears to be perfectly healthy, and the nerve-cells are normal both in numbers and structure.

Owing to the fracture which occurred during the preparation of the bone, the walls of the internal auditory meatus have fallen in. Two very small areas of otosclerotic bone are found in the walls of the internal auditory meatus; one on the anterior and one on the posterior wall.

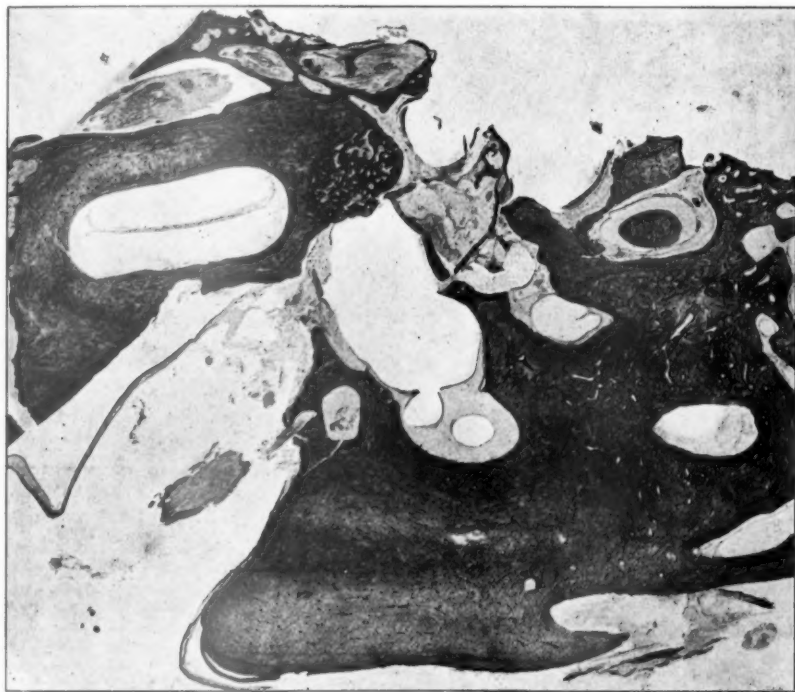


FIG. 4, Case II.—Right ear. A comparatively large area of newly-formed bone is seen in the wall of the anterior extremity of the oval window, but there is no ankylosis. A very small patch of newly-formed bone is present in the posterior wall of the oval window. The footplate of the stapes is unaffected.  $\times 10$  circa.

On examination of the cochlear nerve, distinct evidence of pathological changes are found. These consist of patches in which the spiral neurokeratin filament of the fibres had disappeared and similar absence of the neurilemma is observed. As a result of the gaps thus produced in their walls many of the fibres adjacent to one another have open communication between. The axis cylinders are present and show no abnormality, but in the regions in which the spiral filament is absent they tend to lie in contact with the neurilemma and are not always easy to see. When

viewed in longitudinal section the cochlear nerve shows a patchy appearance (fig. 6) resulting from disappearance of the spiral filament and neurilemma above described, and in striking contrast with the normal cochlear nerve.

The vestibular nerve appears to be quite healthy, the neurilemma and spiral filament of the medullary sheath being present, and the axis cylinders lying in their usual place in the middle of the fibres.

*Left ear.*—The tympanic membrane shows no sign of disease, and the tympanic cavity itself is similarly healthy in appearance except in the immediate neighbourhood of the oval window and stapes. In this region there is a fair degree of thickening

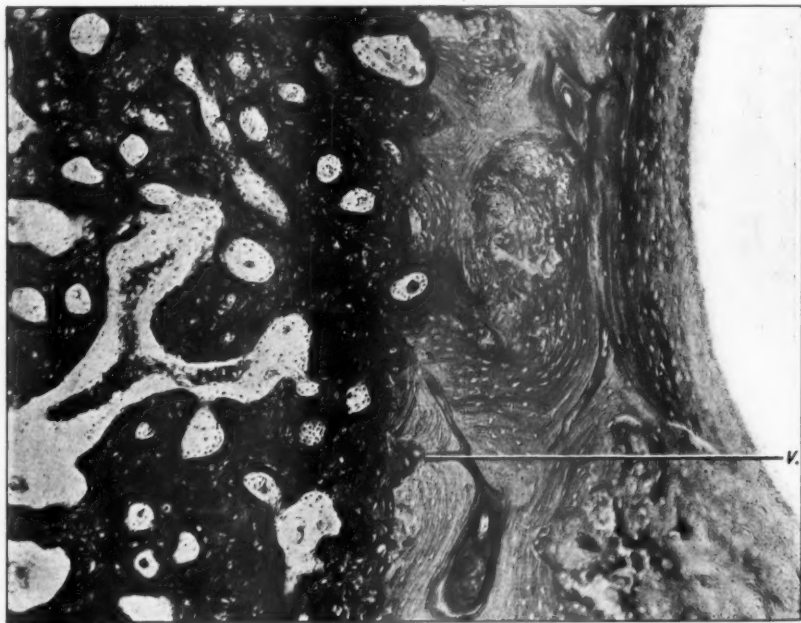


FIG. 5, Case II.—Right ear. Line of demarcation. A dilated vein, *v*, is shown running from the normal bone up to the line of demarcation and there ending abruptly where the transformation of the bony tissue is just beginning to occur.  $\times 150$  circa.

of the muco-periosteum, due to the development of fibrous tissue between the bone and the epithelium of the middle ear. It is limited strictly to the area bounded anteriorly by the margin of the otosclerotic bone in front of and behind the oval window. The remarkable feature about this fibrous tissue is the way in which it has produced absorption of the bony tissue of the stapes. It will be seen in fig. 7 that the whole of the posterior crus has disappeared, and of the anterior crus only a fragment remains. The footplate still remains intact.

A comparatively large area of newly formed bone is found in the usual place in the capsule of the labyrinth in front of the oval window. This area extends forward for several millimetres. It does not quite reach the wall of the lowest

whorl of the cochlea. Externally it extends to the wall of the middle ear, and internally it forms a portion of the wall of the vestibule. It extends to, but does not involve, the stapedio-vestibular articulation, and there is therefore no bony ankylosis at the anterior extremity of the joint. The footplate of the stapes is not the seat of any new bone-formation, except in a minute area at its extreme posterior termination. This area extends across the articulation into the adjacent region of the wall surrounding the posterior portion of the oval window. A sharp line of demarcation separates this otosclerotic area from the normal bone surrounding it.

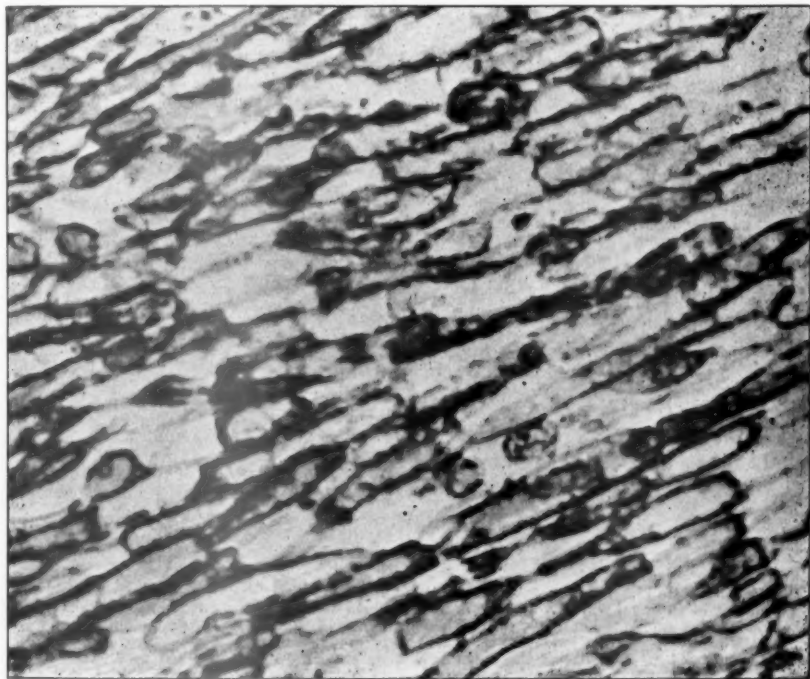


FIG. 6, Case II.—Right ear. Longitudinal section of right cochlear nerve. The neuro-keratin filament is disintegrated in many parts, and this gives rise to the appearance of large gaps in the course of the nerve-fibres.  $\times 300$  circa.

Both the areas of newly formed bone in front of the oval window and that behind it show all the characteristic features of typical otosclerotic bone. It takes up the hæmatoxylin stains greedily, is porous in texture with large spaces filled with marrow, and its edges are sharply defined by the line of demarcation.

The cochlear nerve shows appearances almost identical with those already described as occurring on the right side. The neuro-keratin filament is degenerated and to a large extent has disappeared, and the fragments left show little faculty

for taking up the hæmatoxylin stain (fig. 8). On longitudinal section many gaps are seen in the fibres, owing to this breaking down of the filament. Gaps in the walls of the fibre are also present owing to a similar but less extensive degeneration of the neurilemma. The axis-cylinders on the other hand are present in normal numbers and stain in a normal fashion. Instead of lying in the middle of the fibre, however, they tend to gravitate to the side and lie in contact with the neurilemma. The vestibular nerves are perfectly normal in appearance.

Before passing on to consider the cause of otosclerosis it is necessary to recall some other cases recorded by the writer because they demonstrate facts which have

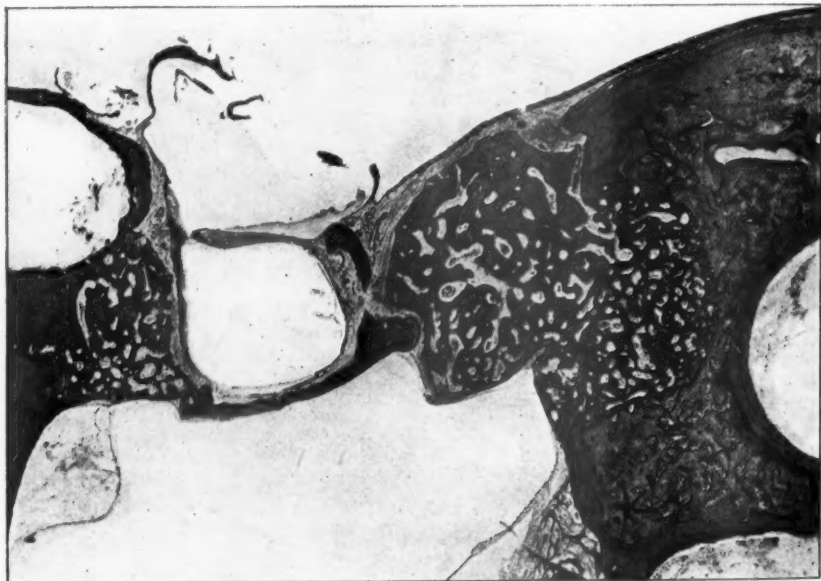


FIG. 7, Case II. —Left ear. A comparatively large area of newly-formed bone is present in front of the oval window. There is no ankylosis at the anterior extremity of the oval window. A small area of newly-formed bone is shown in the wall at the posterior extremity of the oval window, and it will be seen that bony ankylosis has occurred. The footplate of the stapes is unaffected, but the crura have been almost entirely absorbed by the newly-formed fibrous tissue in the muco-periosteum (see text). Note the remarkable symmetry in the arrangement of the newly-formed bone in right and left ears (figs. 4 and 7).  $\times 25$  circa.

frequently been ignored, with the result that fallacious statements have been made, and incorrect theories formed in regard to the nature of the disease.

It is constantly assumed that the change in the bone in otosclerosis *always* consists in the absorption of a portion of the normal bone surrounding the labyrinth and the deposition of new bone to an extent greater than that absorbed. This statement is true in the great majority of cases but there are occasional exceptions. In the writer's work on otosclerosis,<sup>1</sup> in the pathological section an example (Case II) is shown in which the bony tissue in the affected area was absorbed and no new bone at all was laid down. In the same work (Case IV)

Gray, "Otosclerosis: Idiopathic Degenerative Deafness," H. K. Lewis, 1917.

may be seen two types of bony change in one temporal bone. The change in front of the oval window and in the footplate of the stapes shows typical otosclerotic bone, but in the region behind the oval window the absorption of bone is going on more quickly than the deposition, and the texture therefore is quite different from that in typical otosclerosis. It is more like that found in osteitis deformans.

We are not justified, therefore, in speaking of the change in the bone in otosclerosis as if all cases were similar. The great majority are so but there are exceptions to the rule, and these must be explained in any theory which attempts to account for the occurrence of the disease.

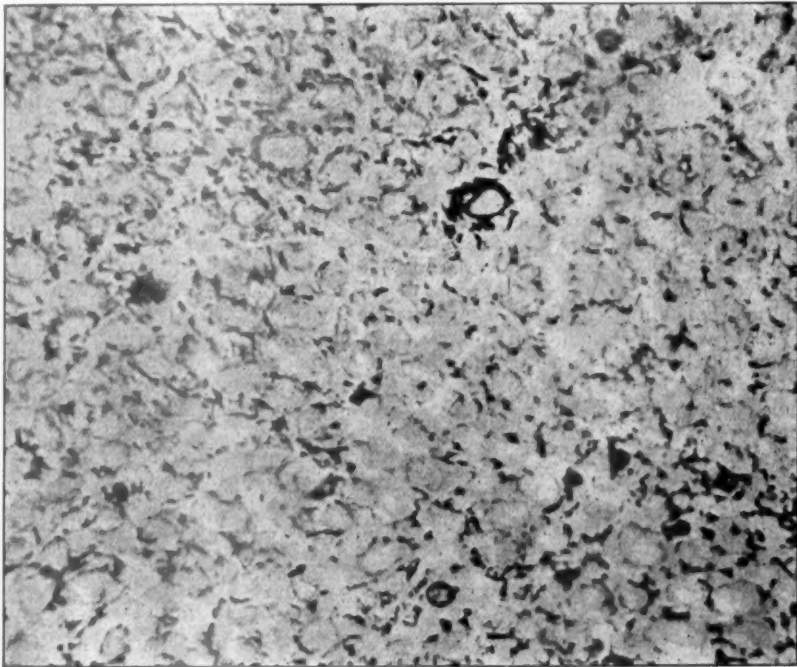


FIG. 8, Case II.—Left cochlear nerve, transverse section. The neuro-keratin filament has to a large extent disappeared, and what is left stains faintly and lies against the outer walls of the nerve fibres. The numerous small black spots scattered throughout the section are the axis cylinders, but they do not occupy the centre of the fibres, as they have lost the support of the neuro-keratin filament.  $\times 300$  circa.

Another very important point is in regard to the extent to which the bony change in the capsule of the labyrinth occurs. It is sometimes assumed that the diseased area keeps slowly extending in all directions. Such is not the case. Usually the anterior limit, at least, remains stationary for many years, and indeed, is frequently determined even at the beginning of the disease. This is demonstrated in Cases III and IV in the writer's work above mentioned, in which the disease had lasted for twenty-five and sixty-three years respectively. No doubt there are cases in which the bony change may slowly advance forwards, but they are not at all common. In the posterior direction the disease is rather more indefinite in its

limitations. In the slow course of time it usually reaches the footplate of the stapes and, extending along the latter, passes over the posterior extremity of the stapedia-vestibular articulation into the margin of the wall of the oval window, and thus causes very complete ankylosis. Even here, however, there are exceptions, as may be shown in Case III,<sup>1</sup> above mentioned. In this case, after twenty-five years, the bony change was limited at its posterior margin to a minute portion of the anterior extremity of the stapes; and the bridge of bone was only a small fraction of a millimetre in width, and in depth was limited to three, or at the most four, consecutive thin microscopic sections of about 20  $\mu$  thickness. This was true of both ears, and it enables us to make this important statement that *the extent of the changes in the bone bears very little relationship to the duration of the disease.*

But this case illustrates another equally important fact in regard to otosclerosis. The deafness in this patient was very severe. The report of the clinical examination is given in the work referred to above,<sup>2</sup> and it shows that the conversation voice was not heard at all by the right ear and only at a distance of one inch by the left ear. The other tests as may be seen showed correspondingly severe deafness for other sounds. But as mentioned above, the bony change in the labyrinthine capsule was of very small extent and the area over which ankylosis existed was very minute. This was true of both ears. We may conclude, therefore, that in otosclerosis *the extent of the pathological changes in the bone bears comparatively little relationship to the severity of the deafness.*

From this case we may also learn something in regard to tinnitus. This symptom was severe and caused the patient great distress. In Case IV in the same work<sup>3</sup> tinnitus, though more or less constantly present, was slight in degree and had hardly troubled the patient at all. In this case the bony change was extensive reaching throughout the whole length of the footplate of the stapes and to a considerable depth into the posterior wall of the oval window, thus causing ankylosis over the whole circumference of the articulation. We may infer therefore, that *the extent of the change in the bone bears no relationship to the severity of the tinnitus.*

*Symmetry.*—The changes in the bone which are found in otosclerosis show a remarkable symmetry, and the symmetry extends even to minute details. This is demonstrated in the cases recorded in the writer's work on otosclerosis<sup>4</sup> and his experience since the appearance of that work has confirmed the fact. So much is this the case that when the changes in the bone on one side have been revealed by microscopic examination it is fairly safe to prophesy that the changes in the other ear will be found to be almost identical. No doubt there may be exceptions to this rule but they must be comparatively uncommon.

Before leaving the subject of the changes in the bone which are found in otosclerosis, it is necessary to consider pathological conditions in the temporal bone which are very similar to the changes found in otosclerosis, but which occur with great frequency in certain other diseases. Jenkins and others have described such changes in the temporal bone in cases of osteitis deformans, Nager and others have described them in cases of fragilitas ossium associated with blue sclerotics, and the present writer has described them in cases of neurofibromatous tumours of the acoustic nerve.

The changes in the temporal bone which are found in cases of osteitis deformans are, indeed, somewhat similar to those found in otosclerosis. The only temporal bone from a case of this kind which the writer has had the opportunity of examining was one kindly lent to him by Mr. G. H. Livingstone of the Ferens Institute. It shows changes in the bone almost identical, not with typical otosclerotic bone, but rather with that described by the present writer in the work already cited.<sup>5</sup> It is Case IV in that work and shows that, although new bone is being deposited, absorption is

<sup>1</sup> Op. cit.<sup>2</sup> Op. cit.<sup>3</sup> Op. cit.<sup>4</sup> Op. cit.<sup>5</sup> Op. cit., p. 138.

taking place more quickly than deposition, with the result that constantly enlarging spaces filled with marrow are being formed.

In regard to the changes in the temporal bone in *fragilitas ossium* with blue sclerotics, the writer has had the opportunity of examining histologically only one case, which was presented to the Ferens Institute by Mr. F. J. Cleminson, who received it from Professor Nager. The texture of the bone appears to be very similar to that found in typical cases of otosclerosis.

In these cases of *osteitis deformans* and *fragilitas ossium*, however, although the changes in the bone resemble closely those characteristic of typical otosclerosis their distribution is very different. In both the changes were distributed over a far greater area than is found to be the case in otosclerosis. The whole bony covering of the cochlea was affected and in the case of *fragilitas ossium* the disease extended into the region of the semicircular canals. It would not be justifiable to say that such widespread changes are never found in ordinary otosclerosis, but if they do occur they must be rare indeed. The writer has never seen such a case.

The changes in the bone described by the present writer as being found in three cases of neurofibroma of the acoustic nerve are identical with those found in typical otosclerosis, and furthermore, in two out of the three cases the locality of the diseased area was the same as that found in otosclerosis, that is immediately in front of the oval window. In the third case the deposit of newly formed bone was found in the apical whorl of the ductus cochlearis. These conditions are described and illustrated in the writer's "Atlas of Otology," vol. ii.

In discussing the bony changes found in otosclerosis mention must be made of the experiments of Wittmaack. He found that by ligaturing the veins surrounding the foramen magnum in the fowl and thus bringing about stagnation of blood in the veins of the bony covering of the labyrinth a change was produced in the bone after some little time had elapsed. New bone was formed round the affected blood-vessels, which showed all the characteristic features of that found in otosclerosis. The significance of this fact will be referred to more fully in the following pages.

In the cavity of the tympanum changes characteristic of otosclerosis are frequently absent altogether. Of course, as Fraser and others have shown, pathological conditions in the middle ear, such as suppurative or other evidences of inflammatory activity, may be found, and indeed may have some causal relationship to the development of otosclerosis in those particular cases. But these changes are not actually characteristic of otosclerosis and are frequently present when the latter disease is not. Apart from such changes, however, there is one which, so far as the writer is aware is really characteristic of otosclerosis though it is not met with very frequently. This condition is illustrated in the writer's "Atlas of Otology," p. 65. It consists in what appears to be degenerative change in the muco-periosteum of the middle ear. The muco-periosteum is thickened and there is a great development of fibrous tissue. There is no round-cell infiltration, the blood-vessels are not dilated and there is no evidence of inflammatory activity. In all the cases hitherto examined the change is limited to the region of the stapes and oval window. This degenerated muco-periosteal tissue has the power of absorbing the otosclerotic bone over which it lies, and in the case referred to above this absorption has reached an extreme degree, so that a very considerable portion of the otosclerotic bone has disappeared from the footplate of the stapes and the adjacent region in the anterior wall of the oval window. But the activity of this degenerated muco-periosteum is not restricted to the absorption of the otosclerotic bone alone. It may cause absorption of the normal bone of the crura of the stapes though to a less extent.

Pathological changes in the inner ear and the acoustic nerve were, until recently, assumed to be absent or if present were accepted as being secondary to the changes in the bony capsule of the labyrinth. In the year 1932, however, the present writer demonstrated changes in the cochlear nerve in a series of cases of

otosclerosis, some of which had been examined clinically during life.<sup>1</sup> These were of the nature of a degenerative change in the medullary sheath and neurilemma of that nerve, the vestibular portion of the eighth nerve being found to be normal. It was found that the neuro-keratin spiral filament of the medullary sheath was in a condition of disintegration and had in many parts disappeared altogether. The neurilemma also was affected and had disappeared in parts, so that numerous large spaces were formed and the axis-cylinders of the fibres in the affected patches were no longer insulated. This change was found even in early cases of otosclerosis before ankylosis at the stapedio-vestibular joint had occurred. Deafness was present even in these early cases; a fact which proves that the deafness of otosclerosis is by no means entirely dependent upon fixation of the stapes. It is important to observe that the axis-cylinders, although no longer insulated, were present in their usual number and absorbed the stains in the same way as do normal healthy fibres. In respect to the fibres of the vestibular nerve and those of the semicircular canals, it is to be noted that they were quite healthy and showed marked contrast with the diseased fibres of the cochlear nerve.

The structures within the cochlea show little or no pathological changes in otosclerosis, except perhaps in the very latest stages of the disease. The organ of Corti shows nothing more than the post-mortem disintegration which is always found in normal hearing individuals, because in the human subject fixation of the tissues cannot be carried out immediately after death. The cells of the ganglion spirale are found to be normal in appearance in otosclerosis even after the disease has existed for many years.

These then, briefly described, are the pathological changes which have been found to occur in otosclerosis. From our knowledge of the clinical symptoms, however, we may reasonably assume that other changes in the auditory tracts within the brain may be present, and such may account for those cases in which extremely severe tinnitus is a symptom, as also for those in which the symptom described by Mr. Somerville Hastings as "crossed paracusis" occurs. At present we know nothing of the changes which may ultimately be found in the auditory tracts in the brain in cases of otosclerosis.

Before proceeding to attack the difficult problem of the aetiology of otosclerosis, it is necessary to consider briefly the clinical features of the disease. Only a few words, however, are required for this purpose, since these clinical features are for the most part familiar to every otologist. The deafness need only be referred to in order to emphasize its slow progress and the loss of the low notes of the scale more particularly. Tinnitus may be very slight in degree, but is rarely absent altogether, and of course may be very severe. Paracusis willisii when present is very characteristic of otosclerosis, but it is absent in a large number of cases; and the same may be said of the rosy tint seen in the posterior half of the tympanic membrane. The vasomotor response of the blood-vessels of the tympanic membrane is very sluggish, as was pointed out some years ago by the writer. This sign is rarely if ever absent. The sensitiveness also of the membrane is usually diminished. There is no need to emphasize the relatively much greater loss of hearing by air-conduction than by bone-conduction. Finally, the condition which the writer has described as otosclerosis paradoxica must be mentioned.<sup>2</sup> In these comparatively rare cases a sudden but very temporary improvement in the hearing occurs when certain rapid changes in the distribution of the blood in the body takes place. And these may be correlated with the improvement which occurs when the patient inhales nitrite of amyl.

This brief reference to the clinical features of otosclerosis has been made with the object of emphasizing the fact that any attempt to explain the cause of the disease

<sup>1</sup> Gray, *Proc. Roy. Soc. Med.*, xxv (Sect. Otol.); and *Journ. Laryng. and Otol.*, 1932, xlvii, No. 9.

<sup>2</sup> *Journ. Laryng. and Otol.*, 1923, xxxviii, 141.

must account for the presence of these signs and symptoms. It is, indeed, remarkable how so many of the pathologists who have interested themselves in this subject have become so obsessed with the changes which are found in the bony covering of the labyrinth that they have apparently forgotten the clinical aspect of the problem. Yet the latter really demands attention quite as much as the pathological aspect. But, in addition to the required explanation of the clinical symptoms, the curious association of otosclerotic changes in the bony covering of the labyrinth with *fragilitas ossium*, blue sclerotics, osteitis deformans, and acusticus tumour also demands elucidation. The evidence of hereditary tendency to the disease in many cases is unquestionably a fact and must be accounted for in any attempt to explain its nature. The complexity of the problem therefore appears to be very considerable.

The theories which have been put forward to account for the occurrence of otosclerosis are numerous and varied. Many of them can be described rather as pious opinions without any basis in fact. There is an element of unconscious humour about some, as for example that which attributes the disease to the deficiency of an ovarian hormone, the male human subject having apparently no existence in the scheme of things. In the following pages, however, only those theories which rest upon at least some reasonable basis of fact will be considered.

Wittmaack<sup>1</sup> considers that the changes in the bone in otosclerosis are due to stagnation of blood in the smaller vessels in the bony covering of the labyrinth. He bases his opinion on the result of experiments upon fowls already referred to.

The writer has had the opportunity of examining Wittmaack's preparations, and he is of opinion that the newly formed bone produced as a result of these experiments is in no way different from that which is found in otosclerosis. Furthermore, for reasons which will be given later, the writer also agrees with Wittmaack that these changes in the bone are the result of stagnation of the blood in the smaller blood-vessels. This, however, is an explanation of the changes which occur in the bone in otosclerosis, but it does not account for the occurrence of the disease itself, and Wittmaack himself emphasizes this point. For the obvious question arises: why should the blood stagnate in that particular region in the neighbourhood of the oval window in certain individuals and not in others? And furthermore, why should the tendency to this condition be so frequently transmitted from parent to offspring? While, therefore, Wittmaack's experiments give a satisfactory explanation of the changes in the bone in otosclerosis, they do not reveal the causative factor of the disease itself, with all its varied clinical and pathological phenomena.

Otto Mayer holds the opinion that the changes in the bone are a consequence of processes of repair following splitting of the bone in the neighbourhood of the oval window during the period of growth. But the pathological facts which he cites in support of this view are not very substantial and their relationship to otosclerosis is doubtful. Moreover, this view would at best only explain the changes in the bone, and it fails to account for the other clinical and pathological phenomena which go to constitute the disease.

Nager looks upon otosclerosis as a nutritional disease of the bone. He had the opportunity of examining the temporal bone of a patient in whom otosclerosis was associated with *fragilitas ossium* and blue sclerotics. The points in which the changes in the temporal bone were similar to or differed from those found in ordinary cases of otosclerotics have already been pointed out in the preceding pages. It remains to be added, however, that Nager's view is subject to the same objections as that of Mayer. It may explain the changes in the bone, but the reason for the changes in the cochlear nerve as well as for many of the clinical symptoms remains obscure. In the following pages an explanation will be given which appears to the

<sup>1</sup> *Acta Otolaryngol.*, xiv, fasc. 1 and 2.

writer to account for the association of fragilitas ossium and blue sclerotics with otosclerosis.

Several investigators have put forward the view that otosclerosis arises from some defect in one or more of the internal secretions of the body. It is very difficult either to prove or disprove such theories, but one point which would appear to throw great doubt upon their value is the fact that many patients develop otosclerosis when they are in the best of health. If the internal secretions were defective one would expect to find some other indication of the fact in other disturbances of the health. Still this argument against these theories must not be allowed to carry too much weight. A very minor deficiency or excess of one of the hormones might conceivably be sufficient to affect the organ of hearing without otherwise perceptibly affecting the general health.

The relationship between catarrhal conditions in the middle ear and otosclerosis is a difficult subject to elucidate. Fraser and others attach great importance to catarrhal otitis media along with other infective conditions in the middle ear as factors in the genesis of otosclerosis. It is admitted by Fraser that the subject of the disease must have an inborn tendency towards it in order that the infective conditions may produce their effect. There is clear evidence that some cases of otosclerosis do manifest them either in the course of or very shortly after such a condition as acute middle-ear inflammation<sup>1</sup>, and the natural inference would follow that chronic middle-ear catarrh may play a part similar to that of acute inflammation. It is difficult, however, to decide the percentage of cases in which middle ear infection is the exciting cause, the reason being that individual otologists attach different values to the various signs and symptoms in making a diagnosis. The important point to bear in mind is the fact that the essential agent is the inborn tendency to the disease. Infective middle-ear conditions can only be regarded as exciting causes and are frequently absent.

In his work published in 1917<sup>2</sup> the writer explained how he was led to the opinion that otosclerosis was a degenerative process affecting the whole organ of hearing from the external auditory meatus to the cerebral cortex. With the clinical and pathological experience which the intervening years have brought he feels that that opinion has been more than justified, and furthermore hopes to demonstrate in the following pages the circumstances under which this process of degeneration may occur. Before doing so, however, it is important to emphasize a point which is often forgotten—that the organ of hearing does not include the semicircular canals or the maculae acusticae of the vestibule or the nerve associated with them. These are organs of equilibration, having nothing to do with hearing, and they made their appearance in the course of evolution long before there was any function of hearing at all. Another point which it is necessary to bear in mind is that, while in the writer's opinion otosclerosis is a degenerative change affecting the organ of hearing as a whole, it is not meant to be inferred that the degenerative process must begin simultaneously in all parts. The first part in which the degenerative process begins may be in one case the bony covering of the labyrinth, in another the cochlear nerve and possibly in some cases even the projections of the cochlear nerve within the brain. But according to the view expressed above, the tendency is for the whole organ of hearing ultimately to be involved. The particular portion of the organ of hearing which may first become affected is very possibly determined by circumstances associated with other bodily conditions either local or general. Thus an acute or chronic middle-ear infection would tend to bring about the change first in the neighbourhood of the oval window. Prolonged nervous strain or exhaustion, on the other hand, would tend to precipitate the changes first in the cochlear nerve or its projections within the brain. This probably explains the

<sup>1</sup> Gray, "Otosclerosis," 1917, 35.

<sup>2</sup> *Op. cit.*

clinical fact which otologists have frequently noticed, that tinnitus is the first sign of the disease in quite a considerable number of cases. If the first change occurs in the cochlear nerve or in its projections within the brain it is very easy to understand that the irritation of the nerve-fibres by the degenerative process in its very earliest stage might cause subjective sensations of sound before the fibres had appreciably lost their function of transmitting nerve-impulses. This clinical fact cannot without fantastic speculation be explained by any theory of otosclerosis which would limit the process to disease of the bone.

In the *Journal of Laryngology and Otology*, vol. xxxviii, p. 141, the writer published an article describing several curious cases of otosclerosis in which great temporary improvement of the hearing occurred under certain circumstances. In these cases of otosclerosis paradoxica, as he termed the condition, changes in the distribution of the blood, either locally or over the vascular system as a whole, appeared to be the cause of the temporary improvement. In one case the annual occurrence of hay-fever caused the improvement in the hearing and in another an ordinary acute nasal catarrh increased the hearing power to such a remarkable degree that the patient always looked forward with pleasure to catching a cold. In other cases it occurred after alcohol had been administered for an attack of fainting or when a cold draught of fresh air blew suddenly upon an individual feeling faint and exhausted in a hot stuffy atmosphere. The improvement was obviously the result of a change in the distribution of blood which produced temporarily an increased flow of fresh blood to the organ of hearing. Incidentally it may be mentioned that in all the cases of otosclerosis paradoxica which the writer has seen the patients were also the subjects of paracausis willisii. Since that paper was published the writer has seen several more such cases and the condition is probably much commoner than might be thought. In some of them the improvement in the hearing is similar to that which occurs in patients suffering from otosclerosis when they inhale nitrite of amyl and is due to the action of the vasomotor mechanism in bringing about a pronounced change in the distribution of blood in the body. It was this association, together with the very sluggish and diminished vasomotor reflex of the tympanic membrane which the writer had observed for many years that led him to formulate the explanation of otosclerosis which will be given in the following pages. Before doing this it is necessary to make some observations on the vasomotor reflex act in general in order that what follows may be clear to the reader. But this will be done as briefly as possible and only in so far as it directly concerns the problem under consideration.

When any structure in the body is called into functional activity a larger supply of blood is necessary than when it is at rest. This increase in the blood supply is brought about by the vasomotor reflex system. The stimulus which calls upon the tissue to function directly or indirectly also stimulates the vasomotor nerves which control the blood-vessels supplying that tissue. A dilatation of these arteries and arterioles takes place in the tissue and thus there occurs an increased flow of blood which enables the tissue or organ to continue functioning satisfactorily. In most tissues the increased flow of blood brings about an increase in the bulk of the tissue or organ because the walls of the blood-vessels are resilient and capable of dilatation; and in addition the surrounding tissue in most cases is also resilient and so allows the dilatation to take place. Hence in the case of most tissues and structures, when they function the amount of blood in them is increased. But there are certain tissues in which the degree of resilience is very slight and in these cases the increase in the amount of blood contained in them when they are called upon to function can only be very little. But the rate of flow of the blood through the vessels in such tissues can be increased and thus the functioning tissue receives its extra nourishment. In the case of dense bone the resilience of the tissue surrounding the blood-vessels is absent altogether and the conditions of the circulation are further

complicated by the fact that the nutrient blood-vessels when they enter the bone lose their muscular coat and become adherent to the bony channels in which they run. Consequently in bone the amount of blood can never vary from time to time, and when the bony tissue is called upon to function the cells can only obtain the necessarily increased nutrition by a more rapid flow of blood. And, conversely, when the bone is not called upon to function the rate of blood through it is diminished, but the amount of blood present must remain the same. In consequence the flow must be correspondingly slow. In view of what is to follow, this is an important point to bear in mind.

When the vasomotor reflex to a given organ or tissue is defective it must be pointed out that the cells of that organ or tissue do not die for want of nourishment, because the flow of blood, though not sufficient to enable them to function properly, is still quite sufficient to keep them alive. They may undergo degeneration or they may be destroyed by neighbouring cells or, what is most usual, the tissue may remain in appearance normal.

In the special case of the organ of hearing the vasomotor system behaves in the same way as in other organs and tissue. The stimulus which calls it into activity is sound. When sound-waves reach the ear the tympanic membrane and the chain of ossicles vibrate, the rapidly moving footplate of the stapes puts stress upon the annular ligament and the adjacent bone, and the fluids in the labyrinth, the organ of Corti, the ganglion spirale, the fibres of the cochlear nerve and all its connexions within the brain are called upon to function. On the other hand since the semi-circular canals and vestibule are not concerned in the act of hearing they do not function. When, therefore, sound strikes the ear in a normal individual, a vasomotor reflex or series of reflexes occurs which allows a greater flow of blood to the structures concerned. There may be a possible exception to this statement in regard to the projection fibres of the cochlear nerve within the brain, because it has not yet been shown that the blood-vessels within the brain are supplied with vasomotor nerves. But in all the other structures mentioned the vasomotor reflex occurs, and it is quite possible that the same happens in the blood-vessels which supply the projections of the cochlear nerve within the brain.

Now it is obvious that if this vasomotor reflex response to sound fails to take place properly the organ of hearing cannot perform its functions satisfactorily, and the degree to which this function is reduced will depend upon the extent of the failure of the vasomotor reflex. A very slight sluggishness in the reflex would bring about a degree of deafness which might hardly be appreciable to the subject, and the condition might be a temporary one. In such a case when the vasomotor reflex was restored any deafness would disappear. But let it be supposed that the defects in the vasomotor reflex were due not to a temporary failure of the vasomotor nerve mechanism, but to an inherent weakness resulting from the neurones which govern the reflex very gradually losing their irritability to stimulus. Then the deafness would gradually increase, other changes in the organ of hearing would be liable to occur, and other symptoms supervene. It appears to the writer that these changes taken all together constitute the condition which we call otosclerosis. According to the writer's view, therefore, *the cause of otosclerosis is the partial failure of the vasomotor system of the organ of hearing taken as a whole.*

Such being the view of the writer in regard to the ætiology of otosclerosis, it is necessary to ascertain to what extent it is in agreement with the known pathological and clinical features of the disease; for as was pointed out above, any hypothesis must explain both clinical and pathological facts or at least must not stand in contradiction to any of them.

It is interesting to observe how varied and serious are the clinical features as compared with the pathological changes so far as they are at present known. Among these are the deafness and its slow progress, the tinnitus sometimes occurring

as the first symptom but more often appearing after the deafness, the loss or sluggishness of the tympanic membrane vasomotor reflex, the temporary improvement on inhaling nitrite of amyl and, associated with this, the occurrence of cases of otosclerosis paradoxica. These and other clinical symptoms and general characters create a large and often varied picture when compared with the very limited pathological changes in the bone in the region of the oval window and the degeneration in the sheath of the cochlear nerve, which constitute the only structural changes which are to be found.

The clinical changes may be considered first. On inspection the tympanic membrane shows no change which can be looked upon as being associated with otosclerosis. The membrane in otosclerosis is frequently more translucent than normal, but just as frequently is more opaque, and usually it is normal. The rosy pink tint seen on examination, which when present is so characteristic of otosclerosis, is due not so much to changes in the membrane as to the congestion of the vessels in the muco-periosteum and underlying otosclerotic bone between the oval and round windows. But although the tympanic membrane presents no characteristic change on simple inspection, it does present a striking change when stimulated. It has become less sensitive to irritation as was shown by Fröschels many years ago, and this has been confirmed by the present writer. But a more valuable, because objective, sign of change in the membrane is that striking loss of the vasomotor reflex on stimulation. When the tympanic membrane of a normal hearing individual is subjected to pneumo-massage the blood-vessels along the handle of the hammer at once begin to dilate and become easily visible to the eye. But in cases of otosclerosis it takes some little time to bring about this dilatation, and frequently quite a long time. The writer has observed this for many years but has made no systematic study of the matter in regard to differences in the time required to produce the response. Mr. Ashcroft at the Ferens Institute is at present engaged on a research in this matter, and already has amply confirmed the present writer's observations. In so far, therefore, as the clinical evidence obtainable from examination of the tympanic membrane is concerned, the writer's view of the ætiology of otosclerosis is strongly supported.

From the tympanic cavity itself we can obtain little evidence of clinical symptoms at all in otosclerosis, beyond the fact that inflation does not perceptibly affect the hearing. The more considerable loss of the low than of the high notes, though of great value in the diagnosis, gives us no information as to the ætiology of the disease. And the same may be said of the relatively greater loss of air-conducted than of bone-conducted sound. They both depend upon the diminished mobility of the stapes owing to the bony or other changes in the neighbourhood, but they give us no clue towards elucidating the cause of those changes.

The symptoms referable to the sound-perceiving apparatus do give a certain amount of help, but not very much. Thus the occurrence of paracusis and tinnitus, although they may not directly explain the ætiology of otosclerosis, do indicate that the nerve-structures are involved in the disease, and that it is useless to attempt to explain its ætiology by consideration of the changes in the bone alone. Tinnitus is particularly important in this respect, because in the first place it sometimes precedes the deafness, and in the second place it is apparently impossible to account for it by the pathological changes in the bone or by the ankylosis which these changes bring about. Furthermore, tinnitus is sometimes hardly complained of at all in cases which reveal on post-mortem examination a severe degree of bony ankylosis.

Another clinical manifestation occurring in otosclerosis is the striking but very temporary improvement which results from the inhalation of nitrite of amyl. The writer cannot say whether this response occurs in all cases of the disease, but in all those in which he applied the test many years ago, improvement in the hearing

resulted. It varied in degree but was never entirely absent. It is clear, therefore, that the deafness of otosclerosis is to a considerable extent functional, and cannot be due altogether to the fixation of the stapes or to the changes in the cochlear nerve. Of course, both these conditions must be responsible for the deafness to a considerable extent, but the improvement on inhaling nitrite of amyl is clear evidence that the structures of the organ of hearing are still capable of functioning provided they receive an adequate blood supply. This improvement cannot be due to any process of regeneration taking place in damaged tissues, because it occurs within the course of a few seconds. It can only be the result of restoration of function in tissues that are in themselves fully alive, but are unable to function because they are not receiving a sufficiently large supply of arterial blood.

Closely akin to the effect of nitrite of amyl is that condition first described by the writer and termed by him otosclerosis paradoxica.<sup>1</sup> Since the recording of that condition, the writer has had the opportunity of seeing a few more similar cases, and one of these may be briefly epitomized here. A woman, aged 35, was the subject of typical otosclerosis with tinnitus and paracusis, and came of a family showing a definite hereditary tendency to the disease. On two occasions there occurred a striking but temporary improvement in her hearing which seemed to her inexplicable. On one of these occasions she had been taken for a ride in the side-car of a motor-cycle without a windscreen and at a great speed, and as she described it, she felt smothered with the rush of air all through her head. When she returned to the warm rooms within doors she found that she was hearing much better than she had done for years. This improvement lasted for three or four hours, but had disappeared by the following day. The second occasion was when she was spending an evening with some friends. The room was warm and rather close. She was a strict teetotaler, but that evening she inadvertently took what she thought was a tumblerful of ginger ale, but too late she found that it was some kind of beer or other alcoholic beverage! For half an hour or more she felt a very unpleasant sense of great distension in the head, but curiously enough her hearing became so sharp that she seemed to hear every sound in the room. Within an hour the deafness had returned and the feeling of distension in the head had gone.

In this and similar cases recorded in the paper referred to, the temporary improvement is clearly due to a reflex act in the vasomotor system in general bringing about an increased supply of fresh blood to the cochlea or the cochlear nerve or to the projections of the latter within the brain, which the more local vasomotor system of the organ of hearing, being defective, is unable to do. They lend therefore, considerable support to the view expressed in this paper that otosclerosis is due to a defect in the vasomotor reflex mechanism of the organ of hearing.

Turning now to the pathological aspect of the problem, there are two subjects to consider—the changes in the bony covering of the labyrinth which have been known for many years, and the changes in the cochlear nerve described by the writer two years ago.<sup>2</sup> To these may be added the fibrous thickening of the muco-periosteum over this region of the oval window referred to in this paper. This change, however, is very frequently absent and, when present, appears to be intimately associated with the change in the underlying bone, and may be considered along with it.

The explanations which have been given to account for the change in the bone are numerous. Inflammatory activity has been cited as a cause, but to this view there are many objections. There is no evidence of round-cell infiltration nor of bacterial activity. The remarkable symmetry of the lesions on both sides in the same case appears to be too minute in their details to be the result of any inflammatory agent.

Deficiency in the internal secretions of various glands, such as the thyroids,

<sup>1</sup> *Journ. Laryng. and Otol.*, xxxviii, 141.

<sup>2</sup> *Loc. cit.*

parathyroids, ovaries, etc., has been suggested as a cause of the bony change by several individuals. While it is difficult to disprove such a relationship there are much greater difficulties in the way of accepting it. The subjects of otosclerosis are frequently, and indeed usually, in perfectly good general health, a condition hardly likely to be present if the internal secretions were deficient or excessive in quantity.

For similar reasons it is difficult to accept the view that otosclerosis is the result of some defect in the metabolism of the calcium salts, which leads to abnormal bone-formation. Such an explanation might account for the changes in the bone but it leaves untouched the degenerative changes in the cochlear nerve, as well as other features of the disease such as the sluggish response of the vasomotor reflex in the tympanic membrane, the frequent presence of tinnitus, and indeed many of the signs and symptoms which go to make the clinical picture.

Wittmaack's experiments on the fowl, referred to in the preceding pages, are a valuable contribution towards explaining the changes in the bone. They show that these changes are the result of stagnation of the blood in the smaller vessels within the bony tissue. He is very careful to point out, however, that they do not reveal the cause of otosclerosis, or explain why stagnation should occur in the bone in those individuals who are the subjects of the disease.

Now it appears to the writer that the stagnation of blood in the bone at this particular region is not difficult of explanation if it be admitted that the essential defect in otosclerosis is to be found in the vasomotor mechanism governing the nutrition of the organ of hearing. It has been shown in the preceding pages that in dense bone at any rate, and to a less extent in other very unresilient structures, the amount of blood contained must always remain almost a constant quantity. In the soft structures, on the other hand, the amount of blood present can vary within wide limits, owing to the resilience of the tissues among which the blood-vessels ramify. When, therefore, a bone is called upon to function the extra nourishment which it requires can only be obtained by a more rapid flow of the blood through the bone. This is accomplished by the vasomotor reflex, the nutrient artery of the bone undergoing dilatation in that portion in which it still possesses a muscular coat, that is before actually entering the bone. In this way the rapidity of the flow through the bone is increased and the extra nourishment required during functional activity is supplied, though the actual amount of blood in the bone at any given time is not increased. If, however, this vasomotor-reflex is defective then the increased rapidity in the flow of blood will not occur when the bony tissue is called upon to function in the way of resisting stress, and difficulty in the way of supplying nourishment to the bone cells will be felt most in that region where the stress or tension is greatest. Applying this general rule to the particular case with which we are dealing—the bony covering of the labyrinth—it is obvious that the locality in which changes in the stress, caused by sound vibrations, will be greatest and most variable will be in the region of the oval window. Further, since the movements of the stapes reach their greatest amplitude at the anterior extremity of the bonelet, the stress put upon the wall of the oval window will be greatest at the anterior margin of the latter, and the lines of stress will radiate forwards from there, rapidly diminishing in their intensity as they spread forwards and become dispersed in the thick bony covering of the cochlea. This explains the well-recognized fact that the bony change in otosclerosis almost invariably begins immediately in front of the oval window. The haversian systems of the bone in this region which surround and derive their nutrition from the minute arterioles nearest to the margin of the oval window will be the first to feel the effects of the insufficient blood supply. Furthermore, we are now in a position to give the reason for the spherical outline which the area of otosclerotic bone always shows in its early stage. The haversian systems of bone lie in concentric rings round the nutrient arteriole, and when the

nourishment supplied by that arteriole falls below the demand all these haversian systems will suffer, and the resulting change in the bone will consequently show a spherical outline.

But the hypothesis given here explaining the occurrence of otosclerosis enables us to answer a much more important question involved in the changes which are found in the bone. Why is the newly formed bone so porous in texture? Every pathologist who has considered this question deeply must have felt puzzled. When repair takes place in ordinary dense bone as is the case after fracture of the shaft of one of the long bones the newly formed bone ultimately becomes just as dense as the bone of the two fragments of the shaft which it unites. Why then does the same process not occur in the newly formed bone in otosclerosis? The affected area in the latter case always remains porous in texture, however long the patient may live. An example of this is described in the writer's work on otosclerosis,<sup>1</sup> in which even after the disease had lasted sixty years the porous texture of the otosclerotic area was still typical.

As pointed out in the preceding pages, under normal conditions the extra supply of blood demanded by the bony tissue when actively functioning under the influence of the stress to which it is subjected by the movements of the stapes, is supplied by an increase in the rapidity of the flow of blood, which is brought about by the reflex dilatation of the nutrient artery before it enters the bone; and in this way the texture of the bone remains the same. But when this vasomotor reflex does not take place, increase of rapidity in the blood-flow in the bone does not occur and the bone-cells do not receive the necessary extra nourishment. The result is that these corpuscles, in order to obtain nourishment, begin to eat up the bone which they have already laid down, the process being continued by the osteoclasts which result from the coalition of several neighbouring bone-corpuscles. Spaces are thus formed which allow more blood to pass through the part, and the supply of nourishment is thus increased even though the rapidity of the flow of blood may remain the same. When the supply of nourishment is sufficient the osteoblasts again begin to lay down bone, new haversian systems develop and the lumen of the space formed by the previous absorption becomes diminished. But the encroachment of the newly formed bone upon the spaces can only proceed to a limited extent, because if it went any further the amount of blood present would be lessened and the necessary nutriment for the bone-cells would be unobtainable and reabsorption of the bone would again recur. The spaces, therefore, remain permanently large in comparison with those formed under normal conditions, and the characteristic porous bone of otosclerosis comes into existence. Expressed in another way, we may say that the porous bone holds a larger amount of blood than the normal dense bone in order to compensate in supplying nourishment for the loss which results from the defective action of the vasomotor reflex. Bone-marrow makes its appearance in the comparatively large spaces of the newly formed bone.

Keeping this point in view many of the features of the affected area of bone may be accounted for besides its porous texture. The line of demarcation is sharp and clearly defined because it forms the outer limit of one or more haversian systems which derive their nutrition from one or more arterioles. In a sense, therefore, it may be likened to the sharp line of demarcation which is found in other organs of the body when an infarct occurs following embolism. In the latter case, however, the blood-supply is completely cut off, which of course is not the case in the area of otosclerotic bone.

Another character of the diseased area that now becomes explicable is the limitation of its margins, especially the anterior one. No matter how long the disease has been in existence it is very rare to find the anterior margin of the otosclerotic bone more than two or three millimetres beyond the anterior extremity of the oval window. In the cases examined by the writer the anterior margin of the porous

<sup>1</sup> Gray, *op. cit.*, p. 122.

bone appeared to be as far forward in cases which had lasted two or three years as in those in which the disease had existed for twenty-five and sixty years respectively. The explanation of this fact, according to the writer's view, does not appear to be difficult. The lines of stress which run forward from the anterior margin of the oval window when the stapes is vibrating undergo rapid dispersion as they radiate forward and very quickly become so small as not to affect the living structures in the bone to a degree sufficient to require any perceptible increase of nutrition. The defective reflex vasomotor response to sound-waves, therefore, will not affect those regions. The posterior limit of the otosclerotic bone is rarely found further back than a fraction of a millimetre behind the posterior margin of the oval window and, in many cases, even after the disease has existed for a great number of years it may not have extended so far. Here again, the position of the posterior limit is probably determined by the lines of stress radiating from the margin of oval window backwards into the bony covering of the labyrinth.

In regard to the explanation just given of the anterior and posterior limits of the bony change in otosclerosis it must, of course, be understood that it applies only to the ordinary cases of otosclerosis with which otologists are so familiar. It does not apply to those cases in which similar changes in the temporal bone occur in association with *fragilitas ossium* and *osteitis deformans*. In these conditions the disease is much more widespread than is the case in uncomplicated otosclerosis. In the latter the defect is present only in that vasomotor reflex of which the normal exciting stimulus is sound and sound alone, and consequently any structural changes which may result from the defect will be strictly limited to the organ of hearing. In *fragilitas ossium* and *osteitis deformans* on the other hand, the causative agent, whatever it may be, is not to be looked for in the organ of hearing, and the structural defects are therefore not likely to be limited to the auditory tract as is the case in otosclerosis. Consequently when the temporal bone is affected in these diseases we would not expect to find that the diseased area should be confined within the narrow limits by which it is circumscribed in otosclerosis.

Before leaving the consideration of the changes in the bone which are found in otosclerosis it is necessary to say a few words concerning the development of newly formed fibrous tissue which is sometimes, though perhaps not very often, found in the muco-periosteum which covers the stapes and immediately adjacent portions of the oval window, and is strictly limited to that region. It is no manifestation of chronic inflammation; there is no round-cell infiltration and no dilatation of the blood-vessels. It is obviously the result of a degenerative process in which, as is usually the case, the more primitive type of cell overcomes the more highly specialized and replaces it. An excellent example of this condition is shown in Case II in this paper. It will be seen that in the left ear (fig. 7) the newly formed fibrous tissue has caused the disappearance of the posterior crus of the stapes and also of a large portion of the anterior crus, with the result that the contour of the bonelet is completely lost except in the region of the footplate which has not yet been absorbed. Another interesting example of this condition may be seen in the author's "Atlas of Otology," vol. ii, p. 65. In that case the newly formed fibrous tissue had absorbed a large portion of the newly formed bone in the footplate of the stapes and the adjacent region in front of the oval window. Portions of the crura of the stapes were also absorbed and replaced by the fibrous tissue.

The change in the bone in otosclerosis is usually limited to a single focus, and that is to be found, with the rarest of exceptions, immediately in front of the oval window. Cases do, however, occasionally occur in which two or more foci may be present, and one of these cases has just been described at the beginning of this paper. It is the only one out of eleven with which the writer has dealt in which more than one focus was present. It is necessary to make this brief statement concerning the rarity of multiple foci because it is frequently assumed that they are common.

Turning now to the changes found in the cochlear nerve, it is to be pointed out that we must not yet assume that they are present in *all* cases of otosclerosis. They were first described by the present writer<sup>1</sup> two years ago, and the number of cases is therefore limited. In addition to the four cases recorded in that paper there falls to be added the case reported in this present article, in which also it was found that the cochlear nerve was affected. Hitherto, therefore, the nerve has been found to be affected in all the cases investigated, and this must be considered a characteristic pathological feature of the disease of the same significance as the change found in the bone.

The changes just referred to in the cochlear nerve have already been described and it only remains to consider the cause of these changes. It is necessary first of all to say a few words concerning the structures in which the changes occur, the neuro-keratin filament of the medullary sheath and the neurilemma. The neuro-keratin filament is not in itself a living tissue with cells and nuclei. It is the product of functional activity either of the spongioblasts or of the neurone of which it forms a part. It is not definitely known from which of these living cells the filament is produced, but from the present point of view this is immaterial since both the spongioblast and the neurone are derived from the epiblast. Both, therefore, come of a cellular ancestry, one of whose chief functions is the production of keratin; and the production of the neuro-keratin of the medullary sheath is without doubt merely the continuation of this function in an environment different from that of the surface of the body. The disintegration of the neuro-keratin filament which occurs in otosclerosis may and in all probability does mean the cessation of one of the functions of either the neurone or the spongioblast. It will be shown later that another function of the neurone is suspended in otosclerosis which can be temporarily restored. The neurone, therefore, cannot be dead. This being so, the explanation of the pathological change seen in the neuro-keratin filament in otosclerosis is to be found, according to the view expressed in this paper, in the diminished functional activity of either the spongioblast or the neurone. This diminished functional activity of these cells is the result of insufficient nutrition due to the loss of the vasomotor reflex which governs the nutrition of those cells. When the neurone is called into functional activity by the effect of sound-waves acting upon the organ of Corti and causing a nerve-current to travel the whole length of the auditory tract from the cochlea to the cerebral cortex, then the neurones taking part in this activity must obtain a sufficient supply of blood. This is brought about by the vasomotor reflex of which sound is the exciting stimulus, and if this reflex fails to occur the neurone cannot function properly. And since the production of the neuro-keratin filament is one of its functions the latter is not produced to the normal extent. The organ of Corti, the cells of the ganglion spirale and the axis-cylinders of the fibres of the cochlear nerve show no discoverable change in otosclerosis except perhaps in the latest stages of the disease.

This completes the description of the pathological changes found in otosclerosis. But before leaving the subject it is very necessary to point out that, though no pathological changes can be found in the organ of Corti or in the axis-cylinders or ganglion cells of the auditory tract, a defect of some kind must be present somewhere in these structures. The proof of this lies in the fact that under certain unusual circumstances, such as the inhalation of nitrite of amyl, or in several of the cases of otosclerosis paradoxa described by the writer, the hearing power of the patient suddenly becomes strikingly improved in the course of a few seconds, an improvement which passes off very rapidly. This sudden improvement in the hearing power could not be due to any loosening of the fixed stapes, or sudden regeneration of the medullary sheath of the cochlear nerve. The writer can only

<sup>1</sup> Gray, *Journ. Laryng. and Otol.*, xlvii, 598.

think of one possible explanation and it is this. In otosclerosis the whole system of the organ of hearing, the nerve-tract included, does not receive its normal blood supply because of the loss or diminished sensitivity of the vasomotor reflex. In the unusual circumstances referred to, however, the difficulty is overcome by the sudden redistribution of blood which takes place in the body, and brings to the nerve-cells and fibres a full supply of blood, and with it the oxygen which is of such prime importance for the functioning of the neurone. The result is that the neurones can for the time being function satisfactorily. This appears to the writer to be a satisfactory explanation of the facts in these cases, and indeed he can think of no other possible explanation.

There now remain for consideration three pathological conditions in which changes are frequently found in the temporal bone very similar to those found in otosclerosis. They are fragilitas ossium, osteitis deformans and acusticus tumour of the neurofibromatous type.

Fragilitas ossium is associated with blue sclerotics in 60% of the cases, and with deafness similar in many ways to otosclerosis also in 60%. In 44% all three defects are present together. Mr. J. S. Fraser<sup>1</sup> described three cases in 1919. These were, as is usually the case, hereditary. Mr. F. J. Cleminson<sup>2</sup> has described one in which there was no evidence of inheritance, and Scott and Stobie<sup>3</sup> have given a report of the examination of several members of a family who suffered from fragilitas ossium associated with deafness, which showed many of the signs of otosclerosis. Adams,<sup>4</sup> de Kleijn and other writers have also recorded cases. So far as the writer is aware post-mortem examinations have been made in only two cases. One of these was reported by Ruttin<sup>5</sup> and the other by Nager. Thanks to the kindness of Professor Nager and Mr. Cleminson the writer has had the opportunity of examining the microscopic sections obtained from the latter of these cases. There is no doubt that the changes in the bony covering of the labyrinth are very similar in the two diseases, in so far as the texture of the newly formed bone is concerned. But, as was pointed out above, the distribution of the diseased bone is very different. In otosclerosis the tendency is towards a narrow limitation in the immediate neighbourhood of the oval window, whereas in fragilitas ossium the newly formed bone is found widely spread throughout almost the whole of the bony covering of the labyrinth. This difference is, from the present writer's point of view, easily explained. Otosclerosis is a disease strictly confined to the organ of hearing, and all the other organs and tissues of the body are anatomically and physiologically as healthy as in normal human beings. In fragilitas ossium, on the other hand, the causative factor acts upon structures that are widespread throughout the body, and the bony covering of the labyrinth is only involved as part of the general disturbance.

But as the writer will not admit that otosclerosis is due to some constitutional defect in the endocrine glands, or in the biochemistry of bone-formation, neither can he see any reason to suppose that fragilitas ossium itself is the result of such defects. The disease of the bones known as osteogenesis fibrosa, which bears a superficial resemblance to fragilitas ossium, has been shown to depend upon disease of the parathyroids, but Muir<sup>6</sup> has pointed out that there is no evidence at all that fragilitas ossium (osteogenesis imperfecta) can be associated with any such condition and that the cause of fragilitas ossium is unknown.

It appears to the writer that there is a connecting link between otosclerosis and fragilitas ossium, but it is of a nature different from those usually referred to,

<sup>1</sup> *Proceedings*, 1919, xii (Sect. Otol., 115).

<sup>2</sup> *Proceedings*, xx (Sect. Otol., 13-16).

<sup>3</sup> Stobie, *Quart. Journ. Med. Sci.*, 1924.

<sup>4</sup> Adams, *Journ. Laryng. and Otol.*, xlv, 201.

<sup>5</sup> Ruttin, *Monatsschr. f. Ohrenheilk. und. Laryngo-Rhinolog.*, Heft. 4, S. 53.

<sup>6</sup> Muir, *Manual of Pathology*.

such as endocrine disturbances or aberrant metabolism in bone-formation. Just as, according to the view expressed in this paper, otosclerosis is due to a defect in the vasomotor reflex, of which the stimulus is sound, so fragilitas ossium is due to a defect in the vasomotor mechanism of which the stimulus is stress or tension. Consequently when those structures and tissues whose prime function it is to resist stress or tension are called upon to exercise that function, the increased blood-supply which they should receive does not arrive, and the tissue is unable to develop in the direction of resisting strain or tension. Hence we find that in fragilitas ossium, though the bones are the chief structures which suffer, they are not the only ones. The patients who suffer from the disease are liable not only to fractures, but also to dislocations, because the ligaments are liable to be affected. The sclerotic coat of the eyeball has to resist the stress put upon it by the contraction of the attached muscles, and does not develop the strong fibrous tissue to the normal extent because of the defective vasomotor reflex, and it retains, therefore, the blue colour of early infancy.

The relationship of otosclerosis to osteitis deformans is, up to a certain point, similar to that which it bears to fragilitas ossium. The temporal bone in both cases is involved simply as part of a more widespread disease of bones. But there are considerable differences such as the greater age at which osteitis deformans occurs and the fact that it is more common among men than women. Further, there is no particular evidence of hereditary tendency in osteitis deformans. In all these respects fragilitas ossium appears to have a closer biological affinity with otosclerosis than does osteitis deformans, and to this may be added the fact that the bony change in fragilitas ossium shows a texture more similar to that of otosclerosis than does osteitis deformans.

But it appears to the writer that the relationship of both these diseases to otosclerosis has been unduly stressed. And he ventures to suggest that this has been done in order to prove that the cause of otosclerosis is some constitutional defect in bone metabolism in the body. Now one of the most striking features about the bony change in otosclerosis is its limitation within very narrow limits in the region of the oval window and its equally remarkable symmetry on both sides of the body. There is no evidence whatever that in cases of otosclerosis there is any pathological change in other bones.

The relationship of acoustic tumour to changes in the bony covering of the labyrinth stands in quite a different category from that which exists between these changes and fragilitas ossium and osteitis deformans. Acoustic tumour is definitely a local disturbance of the nerve of hearing even in cases in which it is one tumour out of many in neurofibromatosis. Neurofibromatosis, moreover, is not a disease of bone at all.

The writer has had the temporal bones from three cases of acoustic tumour examined microscopically,<sup>1</sup> and the growths were neurofibromata in all. In all three cases changes were present in the bone identical with those found in typical cases of otosclerosis. Since the deafness began after the symptoms of the acoustic tumour had manifested themselves in all three, it may be assumed that the change in the bone was no mere coincidence but a direct result of the growth. It is necessary to observe, however, that the writer has had the opportunity of examining one case of tumour of the acoustic nerve in which no otosclerotic or other change in the bony covering of the labyrinth was found even on careful examination. This was a case of Dr. de Kleijn's, in which the tumour on the nerve was not a neurofibroma, but a malignant growth secondary to carcinoma of the stomach. This is an important point to remember, because the effect upon the nerve of a rapidly growing and destructively infiltrating malignant tumour would be very different from that produced by the very slow-growing non-infiltrating neurofibromata.

<sup>1</sup> *Proc. Roy. Soc.*, xxv (Sect. Otol., 85-112); *ibid.*, 1938, xxvi (Sect. Otol., 57).

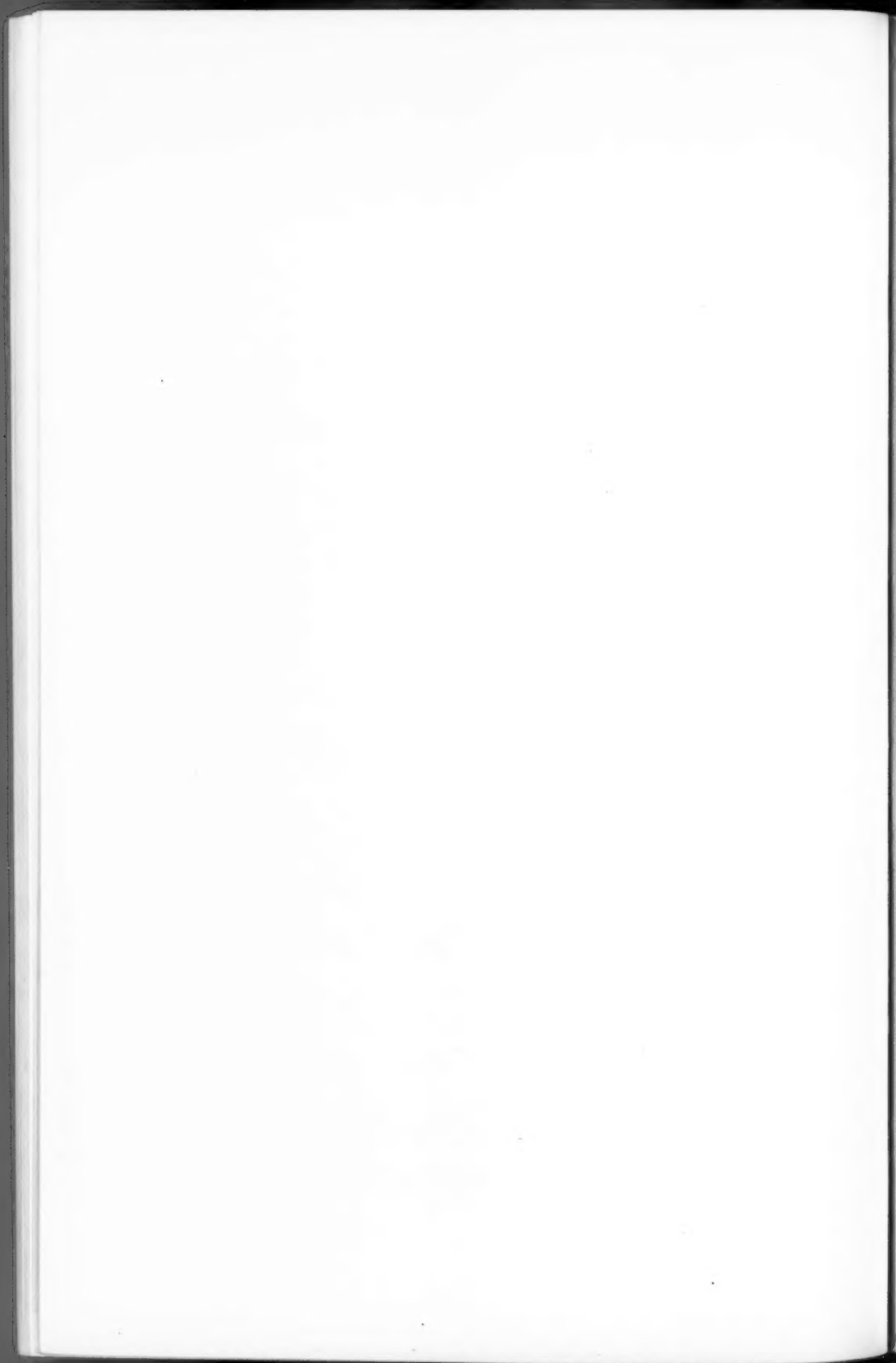
It is difficult to see how this relationship between neurofibroma of the acoustic nerve and otosclerotic changes in the bony covering of the labyrinth can be explained on any other ground than that of interference with the vasomotor reflex of the organ of hearing. The slowly growing tumour exercising a very gradually increasing pressure on the nerve, which contains vasomotor fibres as well as the ordinary auditory sensory fibres, would naturally produce the same effects in the bone as the gradual failure in function of the same nerves which, according to the writer's view expressed in this paper, is the cause of the bony and other changes in otosclerosis.

Women are more frequently the subjects of otosclerosis than men, the relationship being 40% men to 60% women. The usual explanation given for this preponderance of women is that the ovarian hormone (or hormones) act in some way upon the metabolism of bone either directly or indirectly. The fallacy here is, of course, the assumption that otosclerosis is a disease of bone, whereas, as has been shown long ago, the change in the bone is only one feature of the disease.

If otosclerosis be looked upon as a weakness or defect in the vasomotor reflex mechanism of the organ of hearing then the difficulty of explaining the preponderance of women among the victims of the disease disappears. At every menstrual epoch a profound disturbance takes place in the vasomotor mechanism of the organs of reproduction in women. As physiologists point out, a disturbance of the vasomotor mechanism in one part of the body influences all the other parts of that mechanism in the rest of the body, so that the blood can be directed in larger amount to the part where it is required. If there be among these other vasomotor reflexes of the body, one in which the nerve-cells composing it are inherently of rather feeble activity than normal, then it is not difficult to understand how the constantly recurring vasomotor disturbance of menstruation should be sufficient to prevent that particular reflex arc from fulfilling its functions in a normal manner. If the reflex vasomotor arc is that of which the natural stimulus is sound, then the organ of hearing will suffer from the defective action of that vasomotor reflex arc.

When to the vasomotor disturbances of menstruation are added the more severe, but less frequently repeated ones of pregnancy and the puerperium, we can have no difficulty in understanding why the percentage of women sufferers should be greater than that of men.

Heredity plays a considerable part in the incidence of otosclerosis and this, of course, would be expected if the cause of the disease suggested in this paper is correct. The defect in the vasomotor system of the organ of hearing is innate in the individual and not the result of any unfavourable environment. A deleterious environment no doubt can, and frequently does, have an unfavourable effect upon the disease, but this is true of all the functions of the body. The essential factor without which the disease cannot come into existence is innate in the individual and is, therefore, a heritable quality and liable to be transmitted to the offspring.



## Section of Comparative Medicine

President—R. T. LEIPER, M.D., F.R.S.

[April 25, 1934]

### DISCUSSION ON THE RESULTS OF SUTURING DIVIDED NERVES, WITH SPECIAL REFERENCE TO THE TREATMENT OF LARYNGEAL PARALYSIS IN HORSES

**Sir Charles Ballance:** I propose to discuss the operative treatment of paralysis of the vocal cord and of paralysis of the face in man. It is for you to decide whether the methods described or any one of them can be applied for the relief of similar disabilities in the horse.

*Paralysis of the vocal cord.*—On several occasions before the late war I united the peripheral end of the divided recurrent laryngeal nerve to the side of the vagus nerve. These cases could not be followed up.

Mr. Cotterell, F.R.C.S., reported, in 1893, in *The Veterinarian* some experiments connected with the relief of roaring in horses. In 1892 he united the left recurrent laryngeal nerve of a dog to the left vagus; five months later the larynx was reported to have almost recovered. Perhaps this means that the left vocal cord was moving again. He also performed a similar experiment on a donkey, and fifteen months later the larynx was reported to have recovered. Does this again imply that the left vocal cord was moving in tranquil respiration, rhythmically with the right cord? In 1894 Capt. F. Smith reported in *The Veterinary Record* the operation of union of the left recurrent laryngeal nerve with the spinal accessory of the horse. The animal was still a roarer eleven months later, when it was killed. Professor Sheridan Delépine, by electrical stimulation of the spinal accessory nerve central to the site of suture, produced contraction of the abductor muscle. The recurrent laryngeal nerve is described as in a state of partial regeneration.

After the war Mr. Lionel Colledge and I performed a number of experiments on monkeys, uniting the peripheral divided end of the left recurrent laryngeal nerve to various nerves in the neck. When the nerve was united to the descendens hypoglossi or to the vagus nerve, though the cord became straight and tense, there was no abduction movement in tranquil respiration. When the hypoglossal nerve or the vagus nerve central to the site of suture was faradized, abduction of the vocal cord took place. When the recurrent laryngeal was united to the fourth cervical nerve, there was recovery of movement of the vocal cord, but the best results were obtained when the recurrent laryngeal was united end to side to the phrenic nerve. This is not surprising, seeing that the phrenic nerve is one of respiration and that the diaphragm and vocal cords act rhythmically together. If the phrenic nerve is divided and an end-to-end junction by suture is made, the abduction movement of the previously paralysed cord is exaggerated and violent.

I would point out at this stage that in these operations there is no anastomosis of nerves. The distal segment of the nerve degenerates and may then be described as a bundle of tubes containing the broken-up fatty elements of the nerve sheath. The axis-cylinders of the central segment slide along the tunnels, pushing aside the lipid masses till they reach the motor end-organs of the muscle or muscles which

were previously in connexion with the fibres of the distal segment. The new fibres thus replace the old and carry the nerve impulses which again cause contraction of muscle fibres.

What can be learnt from these facts in regard to the treatment of roaring in horses? The experimental findings clearly point to the phrenic nerve as the ideal one to use for union with the recurrent laryngeal, in order to bring about recovery of movement in the paralysed cord. But in the horse the distance between the lower edge of the larynx and the site of suture union of the recurrent laryngeal and the phrenic nerves is fully twenty inches, so that the axis cylinders of the phrenic nerve will have to travel this distance before they reach the intrinsic muscles of the larynx. Can we look forward with satisfaction to this long pilgrimage of the fibres of the phrenic nerve, or would it be preferable to unite a much shorter length of the degenerated recurrent laryngeal nerve to the second or third cervical nerve (anterior primary division)? This question can only be decided by experiment, but I would strongly advise that, whatever operation is selected, it should be carried out without delay, i.e. as soon as roaring is diagnosed. If this is done, the distal segment will be at a stage of degeneration suitable for the growth of axis cylinders from the central nerve segment. Under such circumstances, experimental evidence is in favour of a phrenic-recurrent-laryngeal operation; especially as it is known that the axon grows with remarkable rapidity through a recently degenerated nerve. On the other hand, when operation is delayed, and the peripheral segment is further degenerated and fibrosed, it might be advisable to join a short length of it to the nearest cervical nerve-trunk. Early diagnosis and immediate operation would therefore make for success. Joints immobilized for long periods are prone to ankylosis and the small joints of the larynx are no exceptions to this rule. Another point of importance is that a recently invented laryngoscope, passed through the nasal cavity of the horse, as Major Lloyd kindly demonstrated to me, enables the surgeon to see and determine the exact condition of the vocal cords. He is therefore no longer dependent for his diagnosis on the noise made by the animal when galloped.

*Paralysis of the face.*—I am informed that paralysis of the muscles of the face in horses occurs in consequence of exposure to cold and in consequence of injury.

In man, paralysis of the face occurs in consequence of injury or disease in the region of the aqueduct of Fallopius. Another cause is a stream of cold air striking the side of the face; this is called Bell's palsy, after Sir Charles Bell who first described it. There are other causes of facial palsy that do not concern us.

Since 1895 surgeons have treated facial palsy by uniting the paralysed facial nerve with some other nerve of the neck. Working in collaboration with Dr. Duel of New York, it was concluded finally that in conformity with the fundamental principles of surgery the injury or disease of the facial nerve in the aqueduct of Fallopius should be exposed and treated *in situ*. The damaged portion of nerve was removed and replaced by a fresh nerve-graft, and it was found that this operation gave excellent results in the experimental animals used, viz. baboons, and also in man. In the next stage, for which Dr. Duel was mainly responsible, degenerated grafts were used instead of fresh grafts. A degenerated graft consists of a series of tubes filled with the fatty products due to the breaking up of the sheaths. Through these empty tunnels the axis cylinders from the central segment of the nerve slide along with remarkable rapidity. The result is that faradic response in the paralysed muscles returns in less than half the time that is required when a fresh nerve-graft is employed.

In Bell's palsy, the nerve is inflamed and swollen in the bony canal of the Fallopius aqueduct, the result being paralysis from pressure on the nerve. The treatment for this form is decompression, viz. by removing the outer bony wall of the canal and by slitting up with the utmost care the fibrous envelope of the nerve.

I am not competent to discuss what is the best method of treating paralysis of the face of the horse. I believe a method may be found, though many experiments may be required.

**Lt.-Col. E. P. Argyle :** The condition known as "roaring" is one of the symptoms accompanying degeneration of the left recurrent laryngeal nerve in the horse. The muscles supplied by this nerve are atrophied and fattily degenerated, the first muscle to be affected being the posterior crico-arytenoid, followed later by the adductors. The immediate cause of the "whistling" or "roaring" sound is paralysis of the left vocal cord, so that the passage of inspired air through the glottis is obstructed. Oftentimes the sound does not become audible until inspiration is accelerated by exercise. It is one of the functions of a veterinarian examining a horse for soundness to ascertain that the animal is free from the defect of "whistling," because animals suffering from the condition are useless for fast work, and, indeed, a danger to the life of the rider.

[Colonel Argyle then exhibited a series of lantern slides—all except one being taken from his own dissections—illustrating the disease in question. The pictures showed various stages of the disease in the larynx, and the microscopical appearance of the laryngeal nerve as seen in longitudinal section. The histological features of the degenerated nerve were shown to consist of destruction, atrophy or degeneration of the axons and of replacement fibrosis.]

In two cases indications of degeneration in the laryngeal nerve were seen previous to its reflection round the aortic arch, but round-cell infiltrations were not observed in any case. Mettam [1] stressed the necessity in cases of "roaring" of examining the vagus and spinal accessory nerves at their origin in the medulla. I have found the cells in this region to be atrophied, their nuclei swollen and more faintly stained, with nucleoli eccentrically placed and disintegration of Nissl granules. As the degeneration in such cases is practically confined to cells on the left side, it may perhaps be inferred that the change is secondary to some other condition. At any rate, it is certain that central changes of this sort do occur in "roaring," but it is not yet clear whether these changes remain unilateral in long-standing cases.

With regard to the causation of "roaring" there are several theories: (a) since 1889, the condition has been scheduled as hereditary by the Royal Commission on Horse Breeding [2]. To-day, however, it is doubtful whether this view can be maintained; (b) a nerve poison has been incriminated; generated, it is suggested, in the course of one of the respiratory affections to which horses are liable. Army returns show that 12% of horses which have suffered from respiratory disease subsequently become "roarers," but this is probably a minimal figure [3]; (c) pressure or stretching of the left laryngeal nerve during its intrathoracic course has been thought to be associated with roaring [3 and 4], an opinion which still requires scientific support.

The late Sir Frederick Smith was impressed with the desirability of acquiring further knowledge which might lead to the alleviation of "roaring." Smith was aware of the work of Sir Charles Ballance on nerve suturing, and believed that recurrent laryngeal-phrenic anastomosis would be a means of attaining the desired object. Sir Charles has established the efficacy of this treatment, and, therefore, I would not hesitate to carry it out on horses, provided that suitable cases could be obtained. It is clearly necessary, however, that the cases selected should be early ones, since atrophied muscle does not readily regenerate, and in advanced cases ankylosis of laryngeal joints is liable to occur. Therefore, to ensure success there should be early diagnosis and operation without delay, followed by careful after-treatment and general management.

*Facial palsy.*—Here is a picture [not reproduced] of a case of unilateral (left) facial paralysis in a horse. The paralysis affected the ear, cheek, upper and lower

lips and nostril. Such cases may be complicated by conjunctivitis due to paralysis of the eyelids, difficulty in eating and drinking, and loss of condition. When bilateral, the condition may lead to suffocation owing to failure of the anterior nares to dilate. The causes [5] are given as (a) external injury, e.g. violent contusion; (b) debilitating diseases, such as influenza or purpura hæmorrhagica. It has also been attributed to exposure in cold and draughty stables.

In the case described the condition appeared suddenly and was presumed to be due to some injury. The animal was destroyed, and examination showed advanced degeneration of nerve-cells in the left facial nucleus.

It seems possible that this condition might be alleviated by enlarging the stylo-mastoid foramen, as this is readily accessible in the horse. There is also the possibility that grafting might be successful.

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- 1 METTAM, A. E., *The Veterinarian*, March 1899.
- 2 "Roy. Com. on Horse Breeding" (Evidence before), July-Nov. 1889.
- 3 FLEMING, G., "Roaring in horses," p. 117.
- 4 CLARKE, R. H., *The Veterinary Record*, March 1896.
- 5 MÖLLER and DOLLAR, "The Practice of Veterinary Surgery," 1903.

**Dr. John Beattie**: The appearance of the nerve cells in the cases of "roaring" demonstrated by Colonel Argyle suggests very strongly that the lesion in "roaring" is not nuclear but is more likely to be an inflammatory or mechanical one along the course of the peripheral part of the vagus nerve or of one of its motor branches. There is no inflammatory reaction around the nerve cells. They appear to be atrophied and degenerated in a way quite similar to that observed in motor nerve cells after section of the peripheral nerve.

Sir Charles Ballance has shown the value of nerve anastomosis in the treatment of lesions of peripheral nerves. There are great possibilities in this method provided it can be demonstrated without doubt that the peripheral nerve (recurrent laryngeal), into which the central end of another nerve is sutured, is free from any fibrotic changes. The presence of such changes would not be favourable to a good result.

**Major Glyn Lloyd** exhibited and described the rhino-laryngoscope to which Sir Charles Ballance had referred and which was of great value for diagnostic work in examining the larynx of the horse. Certain modifications of the instrument had been made, so that it could be more easily manipulated. He had examined about ninety horses with this instrument and the view obtained of the vocal cords was clear and distinct. With practice, very little restraint was necessary, and experience proved that the most fractious horse was generally the easiest to deal with. In the normal horse, the vocal cords could be seen moving in a balanced and regular manner during tranquil respiration. In a "whistler" the vocal cord (usually the left—though in one case he had observed the right cord to be affected) could be seen moving in a shaky or lazy manner. In a "roarer" no movement could be detected in the left cord, and the left arytenoid cartilage could be observed to droop towards the lumen of the larynx, so that the larynx appeared to be asymmetrical.

The rhino-laryngoscope gave clear optical proof of the presence or absence of paralysis of the left vocal cord, without galloping the horse and without trusting to the "noise" emitted. Early diagnosis of the condition of the vocal cords was essential if nerve suture for the regeneration of the diseased nerve was to be attempted. As Sir Charles had pointed out, advanced degrees of recurrent laryngeal paralysis might be accompanied by ankylosis of the joints between the cartilages of the larynx.

Major Glyn Lloyd said that he had profited by tuition received from Sir Charles, and on several occasions he had received from him demonstrations of nerve suturing in cats. The possibilities of nerve suturing for the treatment of horses suffering from laryngeal paralysis in its early stages was receiving close attention.

## Section of Obstetrics and Gynecology

President—W. BLAIR-BELL, F.C.O.G.

[March 16, 1934]

### DISCUSSION ON THE PHYSIOLOGY AND PATHOLOGY OF THE PELVIC JOINTS IN RELATION TO CHILD-BEARING

**Mr. Ralph Brooke:** *Anatomy and physiology of the joint.*—Considerable light is thrown on the structure and functions of the human pelvic joints by a study of the more primitive forms. In the less modified fish there are a pair of pectoral fins supported by a pectoral girdle behind the gills, and a pair of pelvic fins supported by a pelvic girdle passing just in front of the anus, and the junction between the axial and appendicular system skeleton is in each case similar.

During the course of evolution the fins become gradually modified as the animal migrates from water to land, and it is only when such a stage is reached that any sign of a sacro-iliac joint may be recognized. The most primitive form of joint is seen in certain amphibia. Many of this group lack a true pelvis, but in others this is not the case. Thus, in anuria, the ileum is greatly elongated and articulates with a single sacral vertebra only. The connexion is a very loose one, but when it is examined microscopically, a complete serous sac, lined with tall epithelium which takes the basic stain deeply, is seen to lie between the bony ends of the sacrum and ileum. This sac is very constant, and is not attached to the bone ends, but lies loosely in the connective tissue between them, surrounded by a capsule of fibrous tissue (see fig. 1).

In the mammalian group, in all pronogrades the joint is a typical diarthrodial one, that is to say, it is composed of two cartilaginous surfaces opposed to, and moving freely on each other, and held together by means of a complete joint capsule and ligaments, and with a well-defined layer of synovial membrane lining the joint capsule, and attached to the margins of the articular cartilage. There is a direct relationship between the freedom of movement in this joint and the activity of the animal. Thus, in the more rapidly moving pronogrades, the joints are loose and freely movable, and, conversely, in the more slowly moving pronogrades, the joints are less movable and the joint structures are less well defined.

The group Aves, certain reptiles, such as Ornithischia, some of the higher primates, and man, have in common the peculiarity that they have adopted the orthograde posture and mode of progression, which has an important bearing on the structure and mobility of the articulation, for it leads to loss of mobility, in part due to the restriction of the range of movement of the body, associated with the change of posture, but chiefly as a result of the additional strain which is thrust upon the joint by the additional weight of the upper part of the trunk and the forelimbs.

In Aves, as economy of weight is essential, the joint has lost its movement completely and has become converted into a synchondrosis. In the higher apes, where

the orthograde method of progression is occasional only, the joints are more movable than in man, and are half way in development and mobility between the orthograde and pronograde forms.

In man the joints are diarthrodial, but there is a tendency, especially in the male when middle age is reached, for the joint to assume the character of a synchondrosis, and to undergo adaptive changes, which, microscopically, resemble very closely the appearance of the joints of birds.

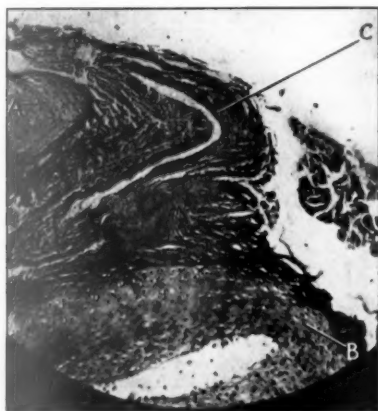
Ages ago, when our ancestors decided to assume the upright position, they were so well pleased with the horizontal axis of the sacrum, that they let it remain almost in its original position, but they developed such a marked lumbar curve that the forelegs left the ground completely. By doing so they not only deprived the forward end of the spine of its original support, but they actually added the weight of the forelegs to the burden of the sacro-iliac joints.

When quadrupeds stand erect on their hind legs the lumbar vertebræ and the axis of the sacrum are almost vertical. When the human being sits the same is true, but when standing, the lumbar vertebræ assume the characteristic lumbar lordotic curve, whilst the sacrum retains its horizontal axis. Man has to modify and strengthen the joint, not only to meet the additional weight thrown upon the sacrum and the sacro-iliac joints, but to meet as well an increased burden which has been added to structures which have, as it were, been thrown out of their axis; that is to say, the weight is now transmitted through a line approximately at right angles to the line of weight-transmission for which the bone and joints were originally designed and built.

The posterior pelvic joints appear very late in development. Thus, at the fifth month, the joint has only just made its appearance, as a condensation of mesenchyme between the cartilages of the sacrum and the ileum, and differentiation into its component parts has not yet commenced, although in other joints of the body, including the joints of the spine, differentiation into the various joint structures has already been well established. The joint is both developmentally and phylogenetically late in making its appearance. It is not altogether surprising that a joint appearing so late phylogenetically and subjected to the strains previously mentioned, should show changes which are seen in no other joint in the body. There is no other joint which is placed in such a vulnerable position. Adaptive changes must be rapid morphologically, and extensive, and, because of this, possibly incomplete. Such, in fact, is the case, and these joint changes have led to considerable difference of opinion in the past as to its exact nature. There is no doubt that the joint is of the diarthrodial type in the young, and most observers describe it as such (see fig. 1A) although some still classify it as a synarthrosis, and with some justification, for, as age advances, adaptive changes take place which alter its character completely in the male, and less completely in the female. Thus, in the middle-aged male and female, the joint is undoubtedly an amphiarthrosis, and in the male of late middle age, and advanced age, it is a synarthrosis. Actually, so great are these adaptive changes, that it is difficult to place the joint in any one group.

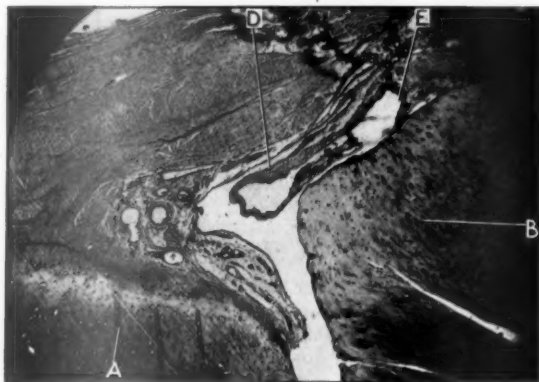
During the first twelve or fifteen years of life it is impossible to distinguish by movements alone the joints of the two sexes, but with the advent of puberty secondary sexual differences appear. In the male the amount of movement does not increase at all, but, if anything, diminishes to a slight extent. The male joint is built for strength and security, and for that reason, as adult life is reached, the ligaments thicken and become stronger, to meet, no doubt, the increased strain in the harder physical task which falls to man's lot. Mobility, in other words, is sacrificed for strength.

In the female, on the other hand, from the age of puberty to 25, a rapid increase in mobility takes place, and at 25 the maximum mobility is attained. It would seem that, in the female, unlike what occurs in the male, strength and solidity are



A = Ilium. B = Sacrum. C = Sacro-iliac joint.

FIG. 1.—The Anurian sacro-iliac joint. The most primitive type of joint. This section shows a serous sac lying in a mass of fibrous tissue. There is no differentiation into joint ligaments or capsule. The ends of the elongated sacrum and the ileum may be seen.



A = Ilium. B = Sacrum. D = Synovial tuft. E = Synovial membrane.

FIG. 1A.—The sacro-iliac joint of a young female. This section shows the anterior end of the joint. It will be seen to be of the true diarthrodial type, with a well marked layer of synovial membrane with synovial tufts and reduplications bridging across the front of the joint and extending from one articular cartilage to the other.

sacrificed in favour of increased mobility, the ligaments and soft parts of the joint remaining comparatively lax, an adaption, again, to function—the probable and natural female function of parturition.

The maximum age-incidence of tuberculosis, infective arthritis, and other sacro-iliac disorders, lies between the age of 20 and 25, which corresponds to the time when the joints are most movable. As would be expected, sacro-iliac disorders occur by far more commonly in female subjects, which, as seen in the Graph (see fig. 2) have the more movable joints, and, at a time when the joints are most movable. In the female there is a gradual diminution in the range of movement from the age of 25 to that of 50, followed by a more rapid diminution from the age of 50 to that of 75. Even at this advanced age there is considerable movement.

In males over 50 years of age 86% of the joints are ankylosed. Under the age of 40 it is uncommon to find bony ankylosis although absence of movement is

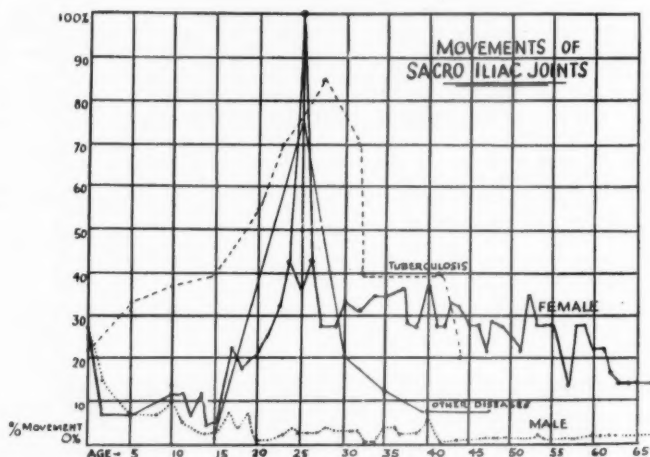


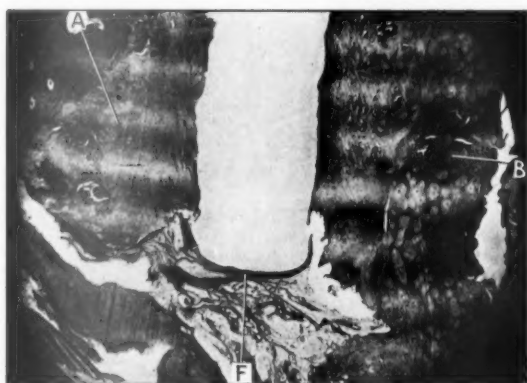
FIG. 2.—Graph showing the movement at the sacro-iliac joint at different ages and in the two sexes. This is based on the examination of 400 specimens. It will be seen that the maximum movement is present at the age of 25 years, and that in the male the movement is very slight indeed. The sharp peak at 25 years represents the movement which is present during pregnancy, at term. The dotted curves represent the age incidence of some of the sacro-iliac diseases. It will be seen that the maximum incidence corresponds to the age when the joints are most movable.

common. Ankylosis, either fibrous or bony, is a characteristic of middle and advanced age. The changes would seem to be in the nature of a retrogression, and microscopically, bear a marked resemblance to the appearance of the joints of birds.

It is possible that this change—in which cartilage cells change to fibroblasts, and finally to osteoblasts, with the formation of bone through fibrous tissue—may be a natural response of the cell to altered conditions, in the shape of increased stress and strain, a natural adaption of a cell late in its evolution, and possibly, thereby, retaining some of its embryological characteristics to meet altered conditions.

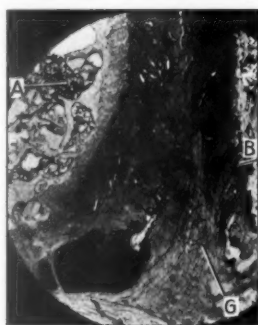
The early undifferentiated mesenchyme of the embryo forms a common mesoblastic stem, from which may develop either fibrous tissue, cartilage or bone, and the cells of these tissues are strictly comparable. Any of these tissues, after a preliminary dedifferentiation to the state of primitive mesenchyme, may be built up

again in the form of one of the other tissues. In the sacro-iliac joints, as a result of prolonged occupational stress in the male, associated possibly with some endocrine change as age advances, the cartilage cells become dedifferentiated and reformed as fibrous tissue. Later the fibrous tissue becomes, through a similar process, converted into bone. This change is not confined to the cartilage, but may be seen in the



A = Ilium. B = Sacrum. F = Bone replacing anterior sacro-iliac ligament.

FIG. 3.—Microphotograph of the anterior part of the sacro-iliac joint showing the adaptive changes mentioned in the text. The anterior sacro-iliac ligament has been replaced by a bony bridge which at one point has fractured.

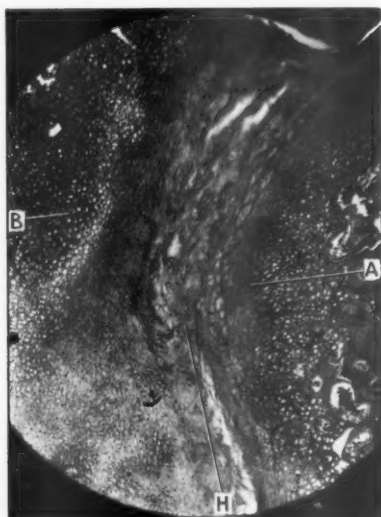


A = Ilium. B = Sacrum. G = Bone replacing joint cavity.

FIG. 4.—A further stage in the adaptive change which is seen in the joints of middle-aged subjects. In this section the joint will be seen to have been completely replaced by a solid mass of bone. There is no sign of a joint cavity, and the joint is completely ankylosed.

capsule and the ligaments of the joint (see figs. 3 and 4). It is not a pathological change, but rather a response on the part of the cell to altered environment, and a change in a cell which has appeared late in phylogenetic development. In the female pregnancy, or the preparation for pregnancy, with possibly some hormonal changes taking place concurrently with this, and the relative absence or slightness of occupational trauma in this sex, lead to the slowing up of the adaptive changes

in the joint, so that the process of dedifferentiation goes only as far as fibrous tissue replacement, and this is delayed, and occurs at a much later date. The stage of reformation in osteoid tissue is never reached (see fig. 5).



A = Ilium. B = Sacrum. H = Fibro-cartilage.

FIG. 5.—An early stage in the adaptive process which is found in the joints of young males and middle-aged females. The joint cavity has become obliterated, and the joint surfaces are joined together by fibro-cartilage.

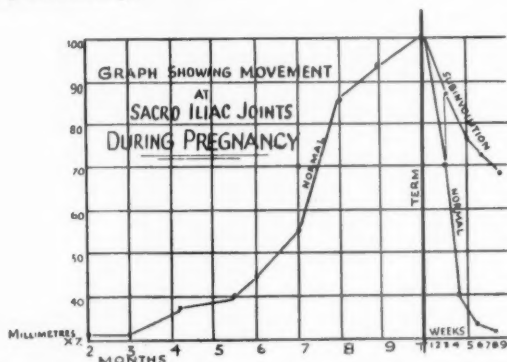


FIG. 6.—Graph representing the changes in the mobility of the sacro-iliac joints during pregnancy. It will be seen that the increase in the mobility is more rapid during the later months of pregnancy. After term the stages of involution are shown. The upper curve shows the influence of delay in uterine involution on the involuntary changes in the sacro-iliac joints.

In the female pregnancy has a great influence on the incidence of sacro-iliac diseases and injuries, owing, amongst other things, to the increased mobility of the joint at that period. At full term the range of movement is increased approximately

two and a half times above the maximum degree present in the non-pregnant woman of the same age.

The increase in mobility during the early months of pregnancy takes place slowly at first, but at the fourth month it is quite easily recognizable. Fig. 6 is a record of these changes in graph form. It will be seen that the rate increases between the fourth and fifth months, becomes progressively greater at the beginning of the seventh month, and then diminishes until term is reached. At no time during pregnancy is the human pelvis in any way frail; neither is this so in rodents or other animals, although there is a popular belief to that effect, based on the loss of function which takes place in the later months of pregnancy in the hind-limbs of certain animals, such as the guinea-pig.

After parturition, the joint returns to its normal state, but slowly; thus, at the eighth week it is still lax, and it is not until the third month that complete stability has been regained. The return of stability is more rapid during the first four weeks, and after that, becomes slower.

The factors responsible for the involuntary changes which take place in the pelvic joints are at present imperfectly understood, but there appears to be a close relation between the involuntary changes in the uterine muscle and those in the ligaments of the joints, for the two processes go hand in hand. It would seem that delay in the involution of the uterus is associated with delay in the involuntary changes in the sacro-iliac joints, and that interference with the one may lead to interference with the other.

It is possible that some of the disabilities and derangements so common in these joints in women after pregnancy, might be prevented if more attention were given to the date of her rising after childbirth, especially in cases in which the puerperium has been complicated, and uterine involution has not proceeded in the normal manner.

In an age freely alive to the benefits of physical culture, games, and outdoor exercises in children, the advantage of such exercise in increasing the general muscular development of the individual must be admitted, but there is no doubt that the pelvic joints have not received the consideration which they deserve. It is impossible to move and exercise these joints in the upright position, for, in that position they are held, and must be held, firm and immovable, to support the weight of the trunk and upper limbs. Free movements can take place only in the prone position, and it is exercise in this position which benefits beyond all others, and increases the function and movement in these joints. Much could be done to prevent the many weary years of backache and suffering which some women are destined to bear, if the authorities responsible for the physical culture of children in schools, would emphasize the importance, to developing young female children, of exercises in the prone position, such as crawling exercises, with a view to making and conserving the small amount of movement which remains in the sacro-iliac joint in that sex, and which will prove so valuable to them when they reach the child-bearing age.

**Dr. R. E. Roberts:** *A radiological investigation.*—The present investigation was undertaken with a view to estimating, by means of X-rays, the nature and precise degree of the physiological changes which normally take place in the pelvic joints during pregnancy. An effort has been made, by the investigation of a large number of cases, to ascertain what is the "standard" or "average" degree of change which occurs.

The ideal mode of procedure would have been to have collected a large group of nulliparous brides and to have traced them through the various stages of their marital career, recording the radiographic appearances and measurements of their pelvic joints at each stage. Owing, however, to obvious limitations of both time and material, such a procedure was impracticable for the purpose of this inquiry. It was therefore deemed expedient to make what use one could of such radiographic

material as was already available. In the case of pregnant women this consisted of several hundreds of skiagrams previously taken for diagnostic information regarding the foetus *in utero*; in the case of non-pregnant women use was made of skiagrams of patients who had been examined by X-rays on account of suspected lesions of the urinary tract. None of these skiagrams, however, had been taken with any special regard to the present investigation of the pelvic joints.

#### RADIOGRAPHIC APPEARANCES OF THE PELVIC JOINTS.

*Symphysis pubis*.—Radiologically this shows a variety of appearances. In most cases the opposing surfaces of the pubic bones are seen to be either flat or



FIG. 1.—Patient lying in supine position with X-ray tube centred vertically above mid point between anterior superior iliac spines. The anterior margin of the sacro-iliac joint is seen to be projected outside the posterior margin. The postero-inferior margin of the joint is marked by an arrow. This was the part of the joint chosen for measurement because of its usual clarity of outline.

wavy, but parallel to each other. In many the gap at the upper end is narrower than that at the lower end; in some the reverse holds, whilst occasionally the symphysis is wider at the middle than at the upper or lower end. When viewed from above, the symphysis is usually seen to be narrower behind than in front.

To choose any one level as representing the width of this joint would therefore appear to be unwise, so the mean width of the joint as a whole has

been chosen as giving the fairest indication of its "width." In most cases this corresponds with the mid-point of the joint.

*Sacro-iliac joints.*—As the sacrum is broader anteriorly than posteriorly, this joint shows very different X-ray appearances when the patient is lying supine from those seen with the patient in the prone position.

(a) In the supine position the divergent X-ray beam passes through the joints obliquely, so that in the radiograph the lines of the anterior margins of the joints lie outside those of the posterior margins (figs. 1 and 2).



FIG. 2.—Skiagram of pelvis with patient in supine position. Note clarity of outline of postero-inferior portion of sacro-iliac joint (marked by arrow).

The only portion of the joint which is seen at all clearly and consistently in all skiagrams is the postero-inferior angle of the joint. For this reason this has been chosen as the part to be measured (figs. 1 and 2).

(b) In the prone position the divergent X-rays frequently traverse the joint more or less directly; for a visualization of the joint as a whole therefore this is usually the better position (fig. 3). Owing, however, to the irregular contour of the opposing surfaces, with elevations fitting into opposing depressions, no part of the joint in this position lends itself to easy measurement.



FIG. 3.—Same case as fig. 2, but with patient lying in prone position. Note lack of clarity of definition of outline of sacro-iliac joints, though the joints as a whole are seen more completely than in the supine position of fig. 2.

#### RELATION BETWEEN THE SIZE OF THE "FILM IMAGE" OF A PART AND ITS TRUE SIZE.

The radiographic or film size of a part such as the symphysis pubis will depend on the distance of the part from the film. The nearer it is to the film the smaller will be its "film size" and the nearer will the latter approach its true size. Conversely the further the part is from the film the larger will be its film image. It is obvious therefore that no reliance can be placed on the width of the film image of the symphysis as measured on a skiagram unless a proper correction be made for its distance from the film. For this purpose we must know (1) the distance of the X-ray tube from the film and (2) the distance of the part in question from the film. The ratio between the "film size" of a part and its true size is shown in figs. 4A and 4B, which also explain the meaning of the term "correction factor."

In the skiagrams available the present investigation had not been foreseen, and no record had been made of the distance of any part either from the tube or film; a method of estimating the appropriate "correction factor" from the film-measurement of the transverse diameter was therefore devised, as follows:—

*Estimation of "correction factors."*—An X-ray tube was fixed above a film at a

distance of 31 ins., which was the standard working distance employed in the taking of all the skiagrams used.

A dried female pelvis of average size (i.e. transverse diameter 13 cms., conjugate 11 cms.) was then placed supine above the film in exactly the same position in relation to the tube and film as would be occupied by the pelvis of a patient when lying in the supine position. The vertical distances between the film and the level

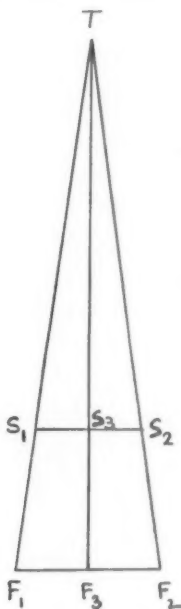


FIG. 4A.

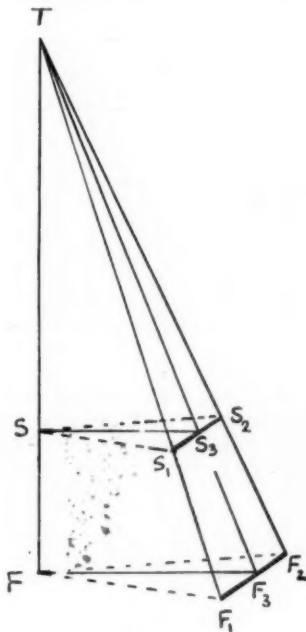


FIG. 4B.

If T represent the focal spot of the X-ray tube;  
If  $S_1 S_2$  represent the symphysis pubis and  
 $F_1 F_2$  represent its "film image" and if  
 $S_3 F_3$  represent their respective mid-points;

$$\text{Then } \frac{S_1 S_2}{F_1 F_2} = \frac{T S_3}{T F_3} = \frac{T S}{T F}$$

$$\text{or } S_1 S_2 = F_1 F_2 \times \frac{T S}{T F}$$

or "true" width = "film" width multiplied  
by the "correction factor"  $\left( \frac{T S}{T F} \right)$

of (1) the middle of the symphysis pubis and (2) the postero-inferior angle of the sacro-iliac joint were measured and the film exposed and labelled. The dried pelvis was now raised about an inch, the distances again measured and another skiagram was taken and labelled. This procedure was repeated till six skiagrams had been taken, each corresponding to a measured vertical height above the film of the middle of the symphysis pubis and of the postero-inferior angle of the

sacro-iliac joint of the dried pelvis. A similar series of films was exposed and measurements were taken with the dried pelvis placed in the normal prone position. The transverse diameter of the brim on each of these films was now measured.

Plotting these various measurements in the form of a graph the correction factor chart shown in fig. 5 was obtained.

For any "film measurement" of the transverse diameter of a patient in the supine position this chart gives (1) the vertical height of the symphysis above

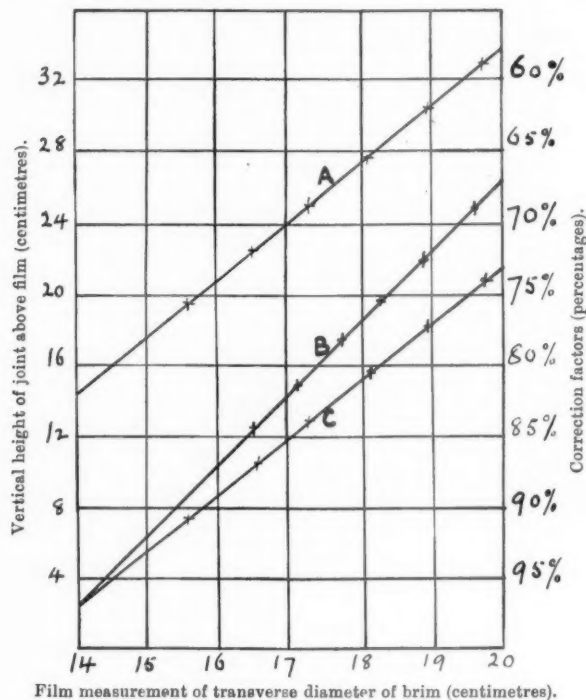


FIG. 5.—CHART OF "CORRECTION FACTORS."

- A = symphysis pubis (supine position).
- B = symphysis pubis (prone position).
- C = sacro-iliac joints (supine position).

By measuring on the film the transverse diameter of the pelvic brim, the appropriate correction factor for the symphysis pubis or sacro-iliac joint can be obtained from this chart.

The film measurement of the joint multiplied by the appropriate correction factor gives its true or actual measurement corrected for its distance from the film.

the film ; (2) the height of the postero-inferior angle of the sacrum above the film. Similarly in the prone position the vertical height of the symphysis pubis above the film is obtained for any corresponding film measurement of the transverse diameter. (For example, if in a certain film taken in the supine position, the transverse diameter, as measured on the film be 17 cms., reference to the chart will show that the vertical height above the film of the symphysis pubis in that case was 24 cms., and that of the sacro-iliac joint was 12 cms., and so on.)

It is now an easy matter to convert the vertical heights of the symphysis pubis and sacro-iliac joints into the percentage distances from the X-ray tube (the tube-film distance of 31 ins. being 100%). The values so obtained are the desired "correction factors" expressed in percentages. (For instance, if in a particular film taken in the supine position the transverse diameter measured on the film be 16.8 cms., and the "film width" of the symphysis as measured on the radiograph be 6 cms., reference to the chart will show that the correction factor for this diameter is 71%; the true width of the symphysis will therefore be 71% of 6 cms., i.e., 4.3 cms.).

By utilization of the appropriate correction factor obtained from this chart, we now have an easy and reliable method of estimating, from our available radiographs, true or absolute measurements of the width of the symphysis pubis and of the postero-inferior angle of the sacro-iliac joint.

#### GROUPING OF CASES AND RECORDING OF MEASUREMENTS.

The radiographs of cases were grouped under the following headings:—

*Non-pregnant*.—(1) Nulliparæ. (2) Paræ.

*Pregnant*.—(1) Primigravidæ. (2) Multiparæ.

For each group the supine and prone radiographs were considered separately (the scale of correction factors being different in the two positions.)

From each skiagram the following measurements were taken: (1) The "film measurement" of the transverse diameter of the brim. (2) The "film measurement" of the mean width of the symphysis pubis. (3) The "film measurement" of the combined width of the two sacro-iliac joints at the level of their postero-inferior angles. (This was obtained by deducting the trans-sacral measurement from the inter-iliac measurement at this level.)

Each measurement so obtained of the symphysis or sacro-iliac joint was then "corrected" for distance from film by application of the appropriate correction factor (obtained from the chart). By this means the true width of each joint in each group was obtained.

#### RESULTS.

(1) *Symphysis pubis*.—The average measurements (corrected for the distance of the part from the film) of the "mean" width of the symphysis pubis in the different groups of cases were estimated to be as follows:—<sup>1</sup>

		No. of patients	Average mean width of symphysis pubis
Non-pregnant	Nulliparæ	69	2.6 mm.
	Paræ	71	2.6 mm.
Pregnant	Primigravidæ	77	4.2 mm.
	Multiparæ	75	5.0 mm.

From this it is seen that an increase in width of the symphysis pubis undoubtedly occurs during pregnancy.

This increase is seen to be greater in multiparæ than in primigravidæ. In the former it is 50% more than in the latter, viz., an average increase of 2.4 mm., as opposed to 1.6 mm.

It is however less than is commonly supposed, and only amounts to about 2.4 mm. even in multiparæ, an increase of less than 100% over the non-pregnant width. It is also seen that after pregnancy the symphysis pubis in the "average" case returns to its normal or pre-pregnant width. How soon this occurs is not yet

<sup>1</sup> It should be emphasized that the results in this table are *average* measurements. Variations from these occur in individual cases. The object of this investigation, however, was to establish a "standard."

The widest symphysis in the group was 10.4 mm. occurring in a primigravida of 26 weeks gestation.

definitely established. In one case radiographed the true measurement of the symphysis pubis nine weeks before labour was 5 mm.; during the first stage of labour it increased to 6.3 mm.; nine weeks after parturition its measurement was 2.9 mm., i.e. it had returned almost to the average non-pregnant width. Further investigation will no doubt provide more precise information on this point.

It should be remarked that the majority of pregnant women examined were in the last two months of gestation. It was noticeable however that in those examined even as early as from the eighteenth to the twentieth week the measurements of the width of the symphysis pubis were quite as great as those examined later. This suggests that the widening of the symphysis pubis occurs at quite an early stage in the pregnancy.

*"Vertical or gliding" movement at the symphysis pubis.*—A number of pregnant women were radiographed in the upright position, with the weight of the body placed on each foot in turn. Vertical riding of the pubic bones on each other could occasionally be demonstrated radiologically. In one such case the total vertical excursion of the pubic bones in relation to each other was estimated from the radiographs to be 5 mm. This patient, a multipara, showed a wide symphysis (8.4 mm.) and wide sacro-iliac joints (6 mm. combined). It would be reasonable to expect that the vertical or gliding movement at the symphysis would be greater in patients with wide pelvic joints than in others.

*The symphysis pubis during labour and in the Walcher position.*—The exact degree of separation of the pubic bones during parturition has not yet been fully investigated. The impression received from the limited number of cases radiographed is that the degree of further separation of the pubic bones during labour is normally only very slight. Skiagrams of a few pregnant women in the Walcher position also suggest that in this position little, if any, further widening of the symphysis pubis takes place. As more material becomes available it is hoped that further and more precise information on these points will be obtained.

(2) *Sacro-iliac joints.*—For reasons mentioned earlier the only portion of the sacro-iliac joint which is considered capable of exact measurement is the postero-inferior angle as shown in supine radiographs.

The results as regards this measurement (corrected for distance from film) are as follows:—<sup>1</sup>

		No. of patients	Combined width of sacro-iliac joints
Non-pregnant	Nulliparae	64	3.6 mm.
	Parae	76	3.9 mm.
Pregnant	Primigravidae	43	4.5 mm.
	Multiparae	61	4.5 mm.

From this it is seen that a slight increase in width (25% in primigravidae) takes place in the sacro-iliac joints during pregnancy. Contrary, however, to the change which takes place in the symphysis pubis, the increased width of the sacro-iliac joints does not appear to be greater in multiparous women than in primigravidae. After parturition the width of the sacro-iliac joints appears to return almost, but not quite, to the pre-pregnant value.

It must be borne in mind that in prone skiagrams not only is the joint as a whole shown better (because of its axis in relation to the divergent X-ray beam) but it is also, especially in pregnant cases, much further away from the film than in the corresponding supine skiagrams—in consequence it looks much wider than it really is. In none of the skiagrams was there any evidence that one part of the joint widened to a greater extent than any other; where widening occurs it appears to do so uniformly throughout the whole joint. This being so, it could be readily

<sup>1</sup> These again are *average* measurements. The maximum combined width of the sacro-iliac joints in the series was 8.6 mm., seen in a full term multipara.

assumed that such a joint in pregnancy would be more capable of a swivel or rotary movement (such as is said to occur in the Walcher position or in the squatting position than would be the case in non-pregnant women. Such widening would also predispose to subluxations, which are reputed to occur as a result of pregnancy.

#### SUMMARY AND CONCLUSIONS.

1. An attempt has been made to estimate by radiographic measurement the exact degree of physiological change which occurs in the symphysis pubis and sacro-iliac joints as a result of pregnancy. In so doing, corrections for distance of the joints from the film are necessary. Where the vertical distance of the joints and of the X-ray tube from the film can be directly measured the "correction factor" can be readily ascertained by means of a sum in simple proportion. As use had to be made of cases in which the heights of the joints from the film had not been recorded when the radiographs were taken, a means of estimating the appropriate "correction factors" from the film measurement of the transverse diameter of the brim has been devised. By applying the "correction factors" obtained by this means the average true or corrected mean width of the symphysis pubis and of the postero-inferior angle of the sacro-iliac joints has been estimated.

2. (a) The results show that in pregnancy the symphysis pubis definitely increases in width in both primigravidae and multiparæ. The average increase in the latter is only about  $2\frac{1}{2}$  millimeters (approximately 100%); and it is 50% greater in the latter than in the former.

(b) After parturition the symphysis pubis in both primigravidae and multiparæ, sooner or later (probably within a few months) returns to its pre-pregnant width.

(c) Vertical or gliding movement at the symphysis can be demonstrated radiographically; it is greatest in cases whose pubic and sacro-iliac joints are widest.

(d) No appreciable increase in width of the symphysis has been observed during parturition. Further investigation however is required before any dogmatic statement on this point can be made.

3. (a) The sacro-iliac joints show a slight increase in width during pregnancy (25% in primiparæ). After parturition they return almost, but not quite, to their normal or pre-pregnant width.

(b) The increase in width of the sacro-iliac joints is uniform throughout the joint.

4. (a) The combined symphyseal and sacro-iliac expansion during pregnancy is normally so slight that the resultant increase in the transverse diameter is almost negligible.

(b) The widening of the symphysis and of the sacro-iliac joints would however lend itself to swivel or rotary movement at the sacro-iliac joints.

**Mr. W. Rowley Bristow:** From the point of view of the orthopædic surgeon, the problem must first be examined from the broad standpoint of the diagnosis of low-back pain and, excluding those cases in which there is a known pathological cause, such as tuberculosis or neoplasm, we must briefly consider certain other conditions: (1) Anomalies of the spine. (2) Arthritis of lumbar spine, especially lumbo-sacral joint. (3) Arthritis of sacro-iliac joints. (4) Fibrositis (myofasciitis). (5) Sacro-iliac subluxation. Chronic strain of ligaments; malposture.

*Anomalies of the spine.*—Anomalies of the spine, particularly about the fifth lumbar vertebra, as revealed in X-ray pictures, are common. In a large series of skiagrams Dr. J. F. Brailsford found some anomaly in 26% of those taken for various purposes, and it is generally agreed by orthopædic surgeons that there is no necessary connexion between say sacralization of the fifth lumbar vertebra and low-back pain.

It is well that we should be clear on this point, for if we focus attention on the congenital variation in the bone we shall miss the true cause of the pain. Sacralization of the fifth lumbar vertebra, spina bifida, a failure of fusion of the laminae, or a long transverse process, are all found as common abnormalities of the skeleton, in X-ray pictures of the spine. We must, of course, examine a skiagram as part of the routine clinical examination, since it may reveal a lesion hitherto unsuspected. For example, a boy had low-back pain, and the general syndrome usually referred to as sacro-iliac pain. The shadow seen in a skiagram was caused by a giant-celled tumour invading the lateral mass of the sacrum.

*Sacro-iliac subluxation.*—There is evidence that the sacro-iliac joint and the symphysis become lax during the later stages of pregnancy. Mr. Roberts has told us that he has measured the widening of these joints in a comparative series of skiagrams. It is widely held that following slight trauma the sacro-iliac joint subluxates with great frequency, and the belief is perhaps rendered stronger by the fact that forcible manipulation is sometimes followed by dramatic cure. Osteopaths and similar irregular practitioners regard "slips" and minor displacements of this joint as of very frequent occurrence. It is a pleasant doctrine, as it is so simple—trifling subluxation, followed by acute and immediate pain—then manipulation and relief!

So far as I know, there is no radiographic proof of a subluxated joint, followed by equal proof that the manipulation has restored the parts to normal. That is to say, the "slip" or subluxation of this joint has to be taken on trust. I find it difficult to believe that it is a frequent cause of low-back pain—if indeed it exists as a clinical entity.

Whilst not denying that the joint becomes lax in pregnancy, I see no proof of the so-called "slip" or subluxation. The pain which we are considering is not confined to the pregnant female, or as a syndrome following childbirth.

Apart from a separation of the symphysis, which is at least not common, there seems to me no essential difference between the symptoms in these patients and in those who have not borne children, or even as seen in the male sex. It is rather the relative frequency in these women that calls attention to the problem.

*Arthritis of the sacro-iliac joint.*—Arthritis of the sacro-iliac joint is, again, admittedly uncommon and is singularly difficult to diagnose.

Much has been written on what is referred to as the "sacro-iliac syndrome." Cochrane of Edinburgh, who worked in Boston and who can fairly present the views of the Boston School of Orthopaedics, writes to me thus:—

"The basis on which I have diagnosed sacro-iliac strain has been very largely the finding of localized tenderness referred to the joint on upward pressure, in the great sacro-sciatic notch and over the posterior aspect of the joint, limited movements referable to the joint, and hamstring spasm limiting straight leg raising."

But does this syndrome really mean a lesion of the sacro-iliac joint? The one gross lesion of the sacro-iliac joint of which we can be sure, by X-ray examination or by direct inspection either at operation or post mortem, is tuberculosis. Now in my experience, sacro-iliac tuberculosis rarely gives definite physical signs. There may be a history of vague discomfort and tiredness extending over many weeks or months, but there may be no local tenderness on pressure, no pain on forcibly moving the pelvis, on forcing the iliac spines apart, or compressing them, or on jarring the joint. These signs are listed in the textbooks as diagnostic of sacro-iliac tuberculosis, but we do not find them in practice. Often the first definite and localizing sign is the abscess, and it is a positive X-ray photograph, or an abscess which establishes the diagnosis. For a skiagram to show change in this deep-seated joint, the change must be gross and of long standing. In the light of this experience, I find it difficult to satisfy myself that the generally accepted signs and symptoms said to locate the trouble to the sacro-iliac joint are to be relied on.

Smith-Petersen has written much on this subject. He has shown a series of

photomicrographs of the cartilaginous lining of the joint, from patients with non-tuberculous arthritis cured by arthrodesis. Clearly, an arthritis of this joint occurs as a clinical entity and calls for treatment, but, whilst the number of patients with low back pain is very great, that of those suffering from a definite arthritis of this joint, calling for a fusion operation, is very few.

*Chronic strain on ligaments from malposture.*—Many good things have come to orthopaedic surgery from the United States, and not least among them is Goldthwait's conception of the effect of malposture. The spinal column is formed of many vertebrae, jointed together. Now, all joints have a normal range of movement, it may be large or it may be small, within which movement is free and painless. Normally, movement beyond this range is prevented by the surrounding muscles, whose action may be compared to that of a brake. The ligaments of each joint are so constituted that no strain falls on them throughout the normal range. If, however, the muscles are taken off their guard by a sudden unexpected movement, or are slowly overpowered by a constantly acting force (such as gravity), the first line of defence, the muscles, gives way and strain falls on the ligaments, and strain on a ligament is characterized by pain, and muscle spasm if the pain is not relieved.

If we visualize the skeleton viewed from the side, the whole weight of the head, arms, thoracic and abdominal contents are transmitted from the spinal column through the rigid sacrum to the ilium, passing through two joints—the lumbo-sacral and the sacro-iliac. Consider the position of the sacrum as it affects the strain on these two joints. Suppose the sacrum is more or less vertical: the lumbo-sacral junction becomes horizontal, and the sacro-iliac joint becomes vertical. Suppose now that the sacrum is more or less horizontal. At the lumbo-sacral junction there will be an anterior sheering force, and the fifth lumbar vertebra will tend to sheer forward off the sacrum, and at the sacro-iliac junction there will be a rotation force, because the weight passes in front of the joint instead of longitudinally through it, and the upper end of the sacrum will tend to rotate forwards and downwards on the ileum. That is to say, the more horizontal the sacrum is, the greater will be the strain on the lumbo-sacral and sacro-iliac joints, and, as a corollary, to lessen strains falling on these two joints, the sacrum must be tilted from the horizontal to the vertical.

During the later stages of pregnancy two factors are present which encourage this change in direction of the sacrum; these are the increased weight of the abdominal contents, and, more important, the stretching of the anterior abdominal muscles; because these anterior abdominal muscles are stretched and weakened, and remain so after parturition.

The muscles responsible for maintaining the sacrum in a vertical, as opposed to a horizontal, position are (1) the extensors of the hip, which, on contraction, tilt the lower portion of the sacrum downwards, and (2) the anterior abdominal muscles which pull the symphysis forwards and upwards. It is my firm belief that the majority of the cases of low backache during pregnancy and post parturition are due to the lack of tone and the lack of use of these two muscle groups.

The basis of sacro-iliac strain is, on this hypothesis, faulty body mechanics, resulting from loss of tone in the abdominal and spinal muscles, rather than a direct injury to the joint itself produced by a definite trauma, comparable to a strain of any other joint, e.g. a sprained ankle.

The result of this upset of body mechanics is that the lumbo-sacral promontory is carried too far forwards, thus increasing the potential of sudden strain upon the joint, and also removing the primary basis of support for the pelvic joints, namely, the muscles which guard them. If these muscles are not really doing their work properly, and strain falls on the ligaments, it is obvious that with the increased vascularity and joint laxity which we know to exist, these will give way. If the patient has this excessive lordosis and poor muscle defence, then any sudden extra

stress occurring, especially during an unguarded moment, may easily strain one of pelvic joints, and lead to localized tenderness, muscle contraction and spasm of the hamstring.

#### TREATMENT.

*Preventive.*—If it be accepted that the majority of these patients are really suffering from postural defects, which the added strain and stresses of pregnancy make manifest, it is obvious that the first essential in treatment is that it should be preventive.

Much needs to be done for the nation as a whole by what is known as physical culture, for in this general faulty posture lie, in all probability, the first causes of the problem we are discussing.

I think something could be done in the ante-natal clinics. For example, these patients could be instructed to correct an exaggerated lordosis during the later months of pregnancy, by wearing a special corset (a Goldthwait brace). I realize that this is a counsel of perfection, not possible for all, and that the busy working woman with five or six other children will often be too tired to benefit by treatment, even if she could and would spare the time, but none the less we should remember prophylaxis. After uncomplicated labour, a postural training may begin early—from the second to the fifth day, and subsequent trouble with low back pain is less common in the clinics where this is the routine.

If the patient is first seen only after symptoms have appeared, what should be our treatment? Feeling myself little qualified to give an authoritative opinion on this subject, I sent out a small questionnaire to several of my friends, and I find that we mostly adopt the same methods.

Granted reasonable mobility of the spine, the first line of attack is to attempt to improve the posture, and to use a belt or brace, both to assist the patient to hold the correct position, and to give the back support. This is no question of massage or haphazard exercises. It is a definite scheme of re-education, which can be summarized thus:—

Teach the patient the correct posture as an exercise, until she can retain it as a habit. That is, the patient must make the correction for herself—re-educate her own muscles and learn to control them and to sense her new position and balance. These exercises are taught with the aid of mirrors and require time and patience and skill.

Next consider the treatment of the patient in whom the mobility of the low spine is markedly limited and in whom free movement is not therefore possible.

Forcible manipulation under anæsthesia is needed—not as an end itself, but rather as the precursor to physical treatment. Under full anæsthesia, the spine, hips and pelvis are forcibly mobilized. In skilled hands, I like avertin as an anæsthetic, sometimes alone, sometimes with gas-and-oxygen, depending on the bravery and experience of the anæsthetist. I find nitrous oxide anæsthesia alone useless for the purpose. The stretching movements may be thorough, forceful, and unhurried, and follow a definite plan, so that all tight structures are stretched.

To instance one manipulation which is of especial value, I would remind you that many of these patients have walked with a backward tilt of the sacrum, and on examination one finds that they cannot stand correctly—that is with the glutei contracted and the lower abdominal muscles tight—because the structures in front of the hip-joint are contracted and are too tight to allow of full extension of the hip. It is obvious that if the hip will not extend fully, the tilt of the pelvis cannot be corrected. In many women, extension of the hip is limited, as can be seen by their mode of gait when viewed from behind, i.e. they are not able to extend their hips, and so rotate their pelvis at every step.

This is one example in which manipulation under anæsthesia is of value; the

tight structures in front of the hip can be stretched. With the anaesthetized patient lying on one side, and one hip fully flexed on the abdomen, the other is slowly forced into extension. In many chronic cases of low backache attributable to pregnancy, I find it necessary to undertake this preliminary manipulation. The manipulation does not aim at putting a bone back, or effecting any miraculous sudden cure. Its object is to increase the range of movement so that the patient can subsequently be taught by a masseuse to acquire and retain a good posture.

The explanation of what the surgeon actually does when he manipulates the pelvis and low spine, is debatable, but in many patients the result is satisfactory. It is certainly possible to rock the ileum on the sacrum and move the sacro-iliac joint, and so presumably to break down adhesions about the capsule. It is equally possible to flex and extend the lumbar spine to its physiological limits and so break down adhesions about the capsule of the joints between the inter-articular processes. It is possible to stretch the lumbar aponeurosis and the muscles of the low back.

On rotating the ileum on the sacrum, it is usual to produce certain "cracks" or "clicks" which can be both heard and felt. This is said to produce a feeling of gratification in the unqualified, but seems to have no pathological significance.

Following the mobilization, hot baths, heat in various forms, and a resumption of exercises under supervision, constitute the necessary after-treatment, the patient being laid up for no more than a day or two. A belt to support the low back is useful and for many patients essential. The type known as the "Goldthwait," or some modification, is the best. It must extend low enough behind to be only just clear of a chair when the patient sits, in order to exert sufficient leverage.

Some surgeons find a longer period of rest advisable. Cochrane tells me that his practice is to strap the pelvic joints after manipulation, and that he keeps the patient quiet for two or three weeks, lying on her back on fracture boards, with a low pillow under the head and under the knees. The strapping is removed on the third day and the patient has massage and postural remedial lying-down exercises to teach her how to flatten the low back voluntarily and to contract the abdominal muscles. When she gets up, a Goldthwait brace and a back-lacing "Spirella" type of corset is fitted.

*Operation.*—Supposing we still fail to effect a cure, i.e. that postural treatment has been tried and has failed, that mobilization also fails, and that the special corset gives no relief, we are at last compelled to operate on the sacro-iliac or lumbo-sacral joint. It is at this point that we feel the uncertainty of diagnosis. One is loath to operate unless one feels that the indications are definite and the chance of cure good, but I, for one, have been driven to operate at times. If the sacro-iliac joint is, presumably, the seat of the trouble, then arthrodesis of this joint is carried out. I use the method introduced by Smith-Petersen of Boston, which consists essentially in exposing the joint from the back, by cutting a window in the ileum. The undersurface of this window is lined by the articular cartilage of the joint, and this cartilage is removed, as is that on the facet of the sacrum which lies at the bottom of the wound. The piece of bone removed is then replaced and countersunk. The operation is easy and produces fixation of the joint with certainty, as the fixation is mechanical. If the case has been correctly chosen, the end-result is satisfactory. Some surgeons fuse the lumbo-sacral joint at the same time or at a second operation.

I have operated on the sacro-iliac joint by Smith-Petersen's operation in eleven patients only. One of these patients, J. C., an unmarried woman, aged 28, was operated on in October 1929, a left sacro-iliac arthrodesis being performed. The immediate result was good and this patient married, and had a baby in 1931. There was no difficulty about labour and she has had no return of pain.

Although the results are good, I find it difficult to persuade myself that the cure is necessarily the direct result of the surgical procedure—even when posture-training, which failed before operation, now succeeds. There is, I am convinced, in

some patients at least, a marked psychical factor, and it may be this, rather than the physical factor, that the operation cures. Be that as it may, operation has been successful in the case of patients who have had pain, unrelieved, for a year or more, by less drastic methods. Yet I would emphasize the fact that operation is not the first line of attack, and should only be undertaken after a fair trial of the non-operation procedures.

**Dr. Kathleen Vaughan** showed a pelvis with elastic joints and pointed out that in the squatting position the ischial tuberosities moved apart, and the sub-pubic angle became wider and allowed more space for the passage of the child's head.

The movement of the pelvis in squatting was like that of the chest in inspiration, a raising of the sides which increased the area enclosed.

This expansion was known to every midwife in the East but the woman must be in the right posture—squatting, or kneeling. It was no doubt in order to loosen the pelvic joints that posture dances played such a large part in education among savage tribes.

She (Dr. Vaughan) had recently been in a French maternity hospital, where she was allowed to deliver the women sitting or squatting. The process was undoubtedly easier and quicker, but of outstanding interest was the joy of the mother at the sight of her child as it was born, which was in marked contrast with the anxiety and questions of the ordinary mother, who did not see her infant until after it was washed. These women were then content to sit, propped up, and await peacefully and happily the expulsion of the placenta.

**Mr. Donald Roy** said that he had recently had the opportunity of noting under anaesthesia the change in size of the transverse measurement of the pelvic outlet in different positions of the patient. He was examining a patient with a generally contracted pelvis, and found that the transverse of the outlet between the two ischial tuberosities measured three inches when the patient was in the extreme lithotomy position but with the thighs markedly abducted. With the patient on her side and the thighs flexed and adducted, the same diameter was increased by a full half inch to three and a half inches. Although the child was not large, as the antero-posterior diameter of the outlet was also small, he anticipated some difficulty. The child was born with great ease, and on measuring its head shortly after delivery the biparietal diameter was found to be three and a quarter inches.

The sort of movement noted in this case probably accounted for the frequency with which difficulty, anticipated at the outlet owing to small measurements in both transverse and anterior directions, did not, in fact, occur. He was disappointed that Mr. Brooke's anatomical researches did not support the view that in older women there was less capacity for movement at these joints and much greater danger of difficulty at the lower strait and outlet. Anything that would enable one to form an idea of the prognosis in outlet contractions would be of the greatest value. The differences of view in the importance of such contractions in different quarters must be due to great variations in the capacity for movement at the joints in different patients.

**The President** said that in the discussion many points had been raised which might have been further considered if there had been time, for example, the effect of sacralization of the last lumbar vertebra of which he himself and also Mr. Roberts had seen a number of cases.

Again, the interesting points mentioned by Mr. Brooke regarding the relaxation of the pelvic joints during pregnancy, by hormonal influences, and the continued relaxation associated with subinvolution of the uterus, were worthy of further investigation.

The discussion had not only brought out much positive information, but had also indicated clearly the lines along which fruitful research might be conducted.

## Section of Medicine

President—Sir FARQUHAR BUZZARD, Bart., K.C.V.O., M.D.

CLINICAL MEETING HELD AT UNIVERSITY COLLEGE HOSPITAL,  
LONDON, W.C.1, ON APRIL 24, 1934

**Vena Azygos Lobe with Hæmoptysis.**—KENNETH HARRIS, M.D., and PETER KERLEY, M.B.

L. G. D., male, aged 24, traveller, complained of cough with hæmoptysis on two occasions seven weeks ago.

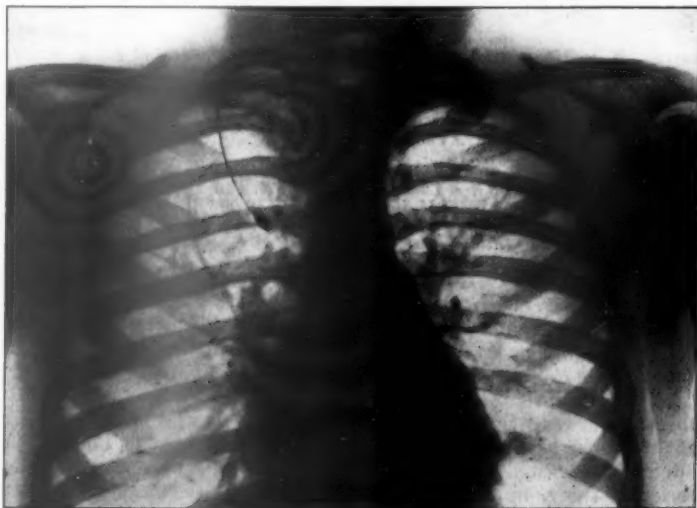
*Present state.*—Slight diminution of movement and increased breath sounds, with prolonged expiration in the first right space.

*X-ray examination.*—No sign of tuberculosis. Characteristic shadow of vena azygos lobe, but with the convexity of the line upwards and inwards instead of downwards and outwards.

**Vena Azygos Lobe in a Child with Chronic Bronchitis.**—KENNETH HARRIS, M.D., and PETER KERLEY, M.B.

R. W., aged 7, schoolboy, complained of chronic winter cough for three years.

*Present state.*—Signs of chronic bronchitis. Breath sounds equal with prolonged expiration at both apices. Sputum: No tubercle bacilli.



*X-ray examination.*—Chronic bronchitis and emphysema. Typical vena azygos lobe with the line curving in the usual direction.

COMMENT. (a) *Clinical.*—Vena azygos lobes have been most frequently discovered in cases of pulmonary tuberculosis, probably because these latter

are more often examined by X-rays than normal cases. Other lesions have been reported such as bronchiectasis and interlobar effusions [4, 5, 6].

(b) *Radiological*.—A fine convex line runs down from the right apex, curving downwards and inwards with the convexity outwards, to end just below the level of the first costal cartilage in a dense, comma-shaped shadow. This was first found in an X-ray picture and described by Wessler and Jaches [1]. There are many variations in the shape of the curved line.

(c) *Anatomical*.—First described in 1778 by Wrisberg; occasionally called "Lobe of Wrisberg." A fold, called the meso-azygos consisting of two layers of parietal pleura with the vena azygos major lying in the free edge, cuts off an accessory lobe of the lung. The azygos lobe is supplied by a small branch of the eparterial bronchus [2] [3].

(d) *Ætiology*.—It has been suggested that this is not a congenital primary defect of the lung, because the bronchus is not a separate branch of the main trunk [3]. There are, however, cases on record in which there was no eparterial bronchus and no upper lobe. A theory has been propounded that it is a defect in the development of the vena azygos major from the posterior cardinal vein. In the fœtus the posterior cardinal vein lies well out on the heads of the ribs and receives a branch from the upper limb, called the posterior marginal vein. Before descent of the heart, this latter vein should atrophy, and thus allow the posterior cardinal vein to be drawn medially. If the posterior marginal vein fails to atrophy the posterior cardinal vein is fixed and the parietal pleura is drawn into a fold, thus marking off an accessory lobe of the lung [4].

(e) *Frequency*.—No definite statistics have been found, though Nelson and Simon suggest that it occurs in 1 in 1,000 persons [9]. One of us (P. J. K.) has recently been investigating its incidence, and has so far found that it occurs much more frequently than this; up to date 1 in 175 or 200 cases examined.

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#### Aortic Aneurysm and ? Syphilis of the Lung: Further Report on Case previously shown.<sup>1</sup>—F. E. SAXBY WILLIS, M.D.

In this case there is undoubted radiological evidence of a general aneurysmal dilatation of the thoracic aorta and the result of the serological tests proves that this is of syphilitic origin. The Wassermann reaction in 1930 was strongly positive, in 1931 positive and in 1934 weakly positive.

During the four years that the patient, now aged 57, has been under observation and treatment there has been an improvement as regards symptoms, but the size of the aneurysm has increased. The skiagrams also show evidence of an interstitial fibrosis in the region of the right hilum, with elevation of the right side of the diaphragm and adhesions, and this evidence, taken in conjunction with the physical signs over the right lung and the comparative mildness of the associated pulmonary symptoms, are consistent with the clinical picture of a syphilitic interstitial fibrosis of the right lung. The treatment given has consisted of two courses of intramuscular arsenic,

<sup>1</sup> At a meeting of the Clinical Section, November 14, 1930. For history of case see *Proceedings*, 1931, xxiv, 279 (Clin. Sect., 21).

and iodide of potash intermittently throughout. There has been an undoubted improvement with regard to symptoms, as a result of treatment, although the patient still has attacks of an atypical bronchitis, with little sputum, but a good deal of dyspnoea. Apart from these, pain beginning over the præcordia, and radiating down the left arm is the chief symptom.

The combination of aortic aneurysm with pulmonary syphilis seems to be rare. No cases are quoted in two recent collections of the literature of pulmonary syphilis namely, those of Hartung and Freedman,<sup>1</sup> and of Olsan and Chambers<sup>2</sup>, and when this case was shown at the Clinical Section's meeting in 1930, Dr. E. Stolkind said that among 61 cases of aneurysm which he had reported, no case of syphilis of the lung had occurred; this being confirmed in cases with autopsy.

**Congenital Complete Heart Block with Charcot-Marie-Tooth Peroneal Muscular Atrophy.**—A. S. HALL, M.B. (by permission of W. J. ADIE, M.D.).

F. G., male, aged 32. Came to the out-patient department complaining of flatulence of five days' duration. History of suspected pulmonary tuberculosis two years previously; had spent three months in a sanatorium. Had also had double pneumonia and measles.

*Condition on examination.*—Large heart with normal sounds, a rough systolic murmur and an occasional diastolic murmur in the mitral area. Heart rate 54; pulsation in veins of neck appeared to be normal. Kyphosis. Knee-jerks and ankle-jerks absent. Plantar responses extensor. Fibrillary tremor in peroneal muscles. Later, an electrocardiogram showed complete heart block, so that the diastolic murmur noted previously was almost certainly an auricular beat. The patient's father had well-marked peroneal muscular atrophy, and it is probable that the son's neurological complaint should be placed in the same group.

A few days later he began to have typical Stokes-Adams attacks, and on admission these were occurring every quarter of an hour. They have been fairly well controlled by injection of 7 minims of adrenalin every four hours.

Blood-urea is 33 mgm. per 100 c.c. Wassermann reaction negative.

Blood-count: 5,330,000 R.B.C. and Hb. 100%. There is now no evidence of pulmonary tuberculosis.

**Three Cases of Pain in the Toes, of Vascular Origin, relieved by Alcohol Injection.**—GWYNNE WILLIAMS, F.R.C.S.

(I) A. O., female, aged 58.

Admitted to hospital February 15, 1934, complaining of pain in the fourth and fifth toes of the left foot. This had begun four months previously; it had disappeared for a while but had persisted during the last three weeks. It was worse when the foot was elevated and somewhat relieved when the foot was dependant.

*Condition on admission.*—Patient looked ill and worn. Urine contained albumin. Systolic blood-pressure was 180.

Both feet were mottled with patches of cyanosis. The veins of the affected foot and leg were dilated. Both feet were of the same temperature and remained so after exposure.

The fourth and fifth toes of the left foot were plum-coloured on the dorsum, the discoloration extended to the base of the toes, and on the plantar aspect it reached proximally about 3 cm. from the toes. The toes were insensitive to light touch. The only artery to be felt pulsating in the left lower limb was the femoral, while on the unaffected side the dorsalis pedis and the posterior tibial could be felt.

Patient was kept in bed for eight days without any special treatment. The

<sup>1</sup> *Journ. Amer. Med. Assoc.*, 1932, xcviii, 1969.

<sup>2</sup> *Calif. and Western Med.*, 1933, xxxix, 185-190; "Syphilitic Pneumonia" (in which article the literature is quoted with 32 references).

colour of the fourth and fifth toes became less deep, and the whole foot lost its cyanosed appearance. There was, however, no diminution of the pain, which kept the patient awake every night.

On February 23, the posterior tibial nerve behind the tibial malleolus was injected with 2 c.c. of 50% alcohol. Anæsthesia resulted over the whole of the sole and the toes, and the patient stated that the pain had disappeared. During the rest of her stay in hospital the pain remained in abeyance, but the area of analgesia diminished, so that the heel and toes became sensitive. The skin on the affected toes peeled and left a normal healthy skin.

(II) H. H., male, aged 86.

Admitted March 8, 1934, with a painful big toe on the right foot. The pain had been gradual in onset since a fracture of the upper third of the tibia six years ago, but had been much worse during the last six months. It was easier when the foot was dependant.

The right foot was discoloured over the dorsum, and the toes were cyanosed. There was a purple patch over the dorsum of the interphalangeal joint of the big toe which did not blanch on pressure. On exposure the affected foot became colder than the opposite one. The only pulsation to be felt in either limb was in the femoral arteries.

The patient was kept in bed for six days without any special treatment, and though the colour of the foot improved, the pain did not diminish, and the patient complained of inability to sleep.

On March 14, 2 c.c. of 50% alcohol were injected into the posterior tibial nerve behind the malleolus, producing anæsthesia of the sole and the toes. On the next day the pain had disappeared from the big toe but was present on the lateral border of the foot and the little toe. On March 17, the pain in the big toe having recurred, the superficial peroneal was injected, in front of the ankle-joint, with 50% alcohol. Anæsthesia in the area of its distribution was produced with resulting disappearance of the pain.

On April 17 pain was still absent, and there was analgesia to pin-prick over the sole but not on the toes.

(III) E. E., female, aged 66. Admitted to hospital March 29, 1934, complaining of pain in the toes of the right foot. This had begun suddenly three years before, and had continued ever since; it had become much worse during the last three weeks. It was relieved by hanging the foot down. The urine contained albumin. Systolic blood-pressure, 200.

The whole of the affected foot was deeply cyanosed, the toes more so than the rest of the foot. On the end of the big toe there was an area of dead skin,  $1\frac{1}{2}$  cm. across. All the toes were very tender. The posterior tibial and the dorsalis pedis arteries could not be felt on the right side; on the left side the dorsalis pedis could be felt. The popliteal artery was pulsating on both sides.

Two c.c. of 50% alcohol were injected into the posterior tibial nerve behind the malleolus and 2 c.c. into the middle of the ankle-joint in front with a view to blocking the superficial peroneal. The pain disappeared immediately and remained absent, although on the next day the analgesia was limited to the area supplied by the posterior tibial. There has possibly been some improvement in the colour of the toes, while the area of the analgesia has tended to diminish, so that on April 17 there was only a small area in the middle of the sole insensitive to pin-prick.

**Traumatic Detachment of Retina Cured by Diathermy.**—C. DEE SHAPLAND, F.R.C.S.

E. B., female, aged 24, first attended hospital on July 7, 1933, with a history of having struck her right temple against a stone mantelpiece two months previously since when she had noticed her right vision defective.

*Examination of eyes.*—Right: White; cornea bright; no keratitis punctata; pupil active; tension normal; good reflex; shallow retinal detachment infero-temporally involving macula with small retinal dialysis at 8.30 o'clock. Vision = fingers at two metres (not improved).

Left: White; cornea bright; no keratitis punctata; pupil active; tension normal; good reflex; fundus normal. Vision =  $\frac{6}{6}$  all (unaided).

*Diagnosis.*—Traumatic detachment of the retina.

17.8.33.—Right eye operated upon by diathermy in the infero-temporal zone 8-12 mm. from the limbus.

4.9.33.—Patient discharged from hospital. Condition of right eye: White; cornea bright; no keratitis punctata; pupil dilated, fixed; tension normal; good reflex; fine vitreous opacities; retina in situ, good scarring infero-temporally, slight pigmentary changes at the macula.

Vision =  $\frac{6}{36}$  all; with - 0.5 sph. =  $\frac{6}{24}$ . Field full.

**Myasthenia gravis.**—T. R. ELLIOTT, C.B.E., M.D., F.R.S. (shown by L. P. E. LAURENT, M.D.).

A. T., female, single, aged 25, has had weakness of the limbs for four and a half years; difficulty in talking, chewing and swallowing, and occasional nasal regurgitation for one and a half years.

First noticed weakness of her arms while attending a gymnasium. Her legs began to give way, and she fell on several occasions. Drooping of the eyelids was noticed soon after the onset. Her symptoms have always been worse in the evening. They also bear a definite relationship to the menstrual periods. She is at her worst during the week that precedes the menses, and she improves during the following week.

Her symptoms have gradually increased—with a few partial remissions of a few weeks' duration. In April 1932, she was at her worst. For a period of forty-eight hours she was completely unable to swallow; she lay in bed on her back and found it impossible to turn over, to raise her head off the pillows or to move her limbs. Attacks of inspiratory dyspnoea which had occurred previously now became alarming in their frequency and severity. Between the attacks her respiration was still laboured, and she had a constant cyanotic hue.

No attempt was made at tube feeding, however, and on the third day she improved remarkably. She was able to swallow a good deal of milk, and her respiration became effortless.

She has been treated at University College Hospital on several occasions since June 1932. Ephedrine was given three years ago, but was abandoned because of the violent attacks of palpitation which resulted.

She has varied very little lately, but she had a severe relapse with respiratory distress for a week preceding her last period which began on April 13, 1934.

*Present condition.*—Fairly well nourished. Pale. Nasal voice. Typical facies with ptosis more marked on the left side. No defect of external ocular movements. Drooping of lower jaw which she supports on her hand while talking or chewing. Marked weakness of all limbs. All forms of sensation unimpaired. Tendon reflexes present, but sluggish; absent during her severe relapses.

**? Endothelioma of Spleen.**—C. BOLTON, M.D. (shown by L. P. E. LAURENT, M.D.).

L. D., housewife, admitted 1.12.33, with the following history:—

Swelling of abdomen for three months. In August 1933 she had an illness, lasting a fortnight, which began with an attack of vomiting followed by slight jaundice.

She quickly improved from this acute phase, but noticed that her abdomen was enlarging.

*Condition on admission.*—A moderately wasted woman. Large abdominal tumour coming from under the left costal margin and having all the characteristics of an enlarged spleen. The lower border was to the right of the middle line. Ascites was easily detectable through the thin abdominal wall. Liver edge palpable three fingerbreadths below costal margin.

A few enlarged lymphatic glands were palpable in the groins and axillæ.

*Blood-count.*—R.B.C. 2,710,000; Hb. 34%; C.I. 0.63; W.B.C. 3,600; lymphos. 74%; polys. 21%; monos. 4%; eosinos. 1%.

Blood Wassermann reaction negative.

The abdomen has been tapped on three occasions and quantities, varying from 9 to 12 pints, of a clear serous fluid were removed.

A microscopical section of a gland removed from the groin showed appearances of an endothelioma.

She has had a lengthy course of X-ray treatment, and this has resulted in temporary disappearance of glands and diminution in the size of the spleen.

**Granular Kidney Eight Years after Acute Nephritis.**—C. BOLTON, M.D. (shown by L. P. E. LAURENT, M.D.).

S. N., aged 21, was treated at University College Hospital in 1925 for an attack of acute hæmorrhagic nephritis which appeared to clear up completely. At the time it was noted that he had an enlarged heart, with mitral stenosis and aortic regurgitation. Blood-pressure was 140; blood-urea 52 mgm. per 100 c.c. He gave a history of scarlet fever at the age of 8 years.

He had been fairly well since until about a year ago when he had hæmaturia lasting two days. On 19.3.34 he attended Dr. Bolton's out-patient clinic on account of attacks of precordial pain and breathlessness. Shortly afterwards he suffered from epistaxis lasting twenty-four hours.

*Condition on admission (2.4.34.)*—A pale man. No pyrexia. No dyspnoea when at rest.

Cardiovascular system: Apex in fifth space 15 cm. from midline. Systolic and diastolic murmurs over mitral and aortic areas. Pulse regular; water-hammer. Blood-pressure 190/70. No oedema. No signs of cardiac failure.

Blood-urea = 250 mgm. per 100 c.c.

Urine contains red cells, albumin and granular casts. Specific gravity 1010.

Urea concentration tests: best result, 0.82 mgm. %.

**Intracranial Aneurysm with Signs of Pressure on the Pons.**—C. BOLTON, M.D. (shown by L. P. E. LAURENT, M.D.).

W. I., a bus driver, aged 34 years, was admitted to University College Hospital on 18.7.32 complaining of numbness and weakness of the right side of the body and right limbs (seven days); blurring of vision and diplopia (seven days); difficulty in swallowing (one day). The onset was sudden with an attack of violent "pins-and-needles" beginning in the leg and working up the right side of the body.

*Condition on admission.*—Fundus oculi, normal; visual fields, normal; marked impairment of external ocular movements. Upward and lateral movements impaired in both eyes. Downward movement apparently intact. Left side of palate weak. Well-marked left facial palsy of lower-motor-neurone type; right hemiparesis with loss of postural sense in right limbs. Right plantar response extensor; left, flexor. Lumbar puncture was not attempted at first as the diagnosis was thought to lie between disseminated sclerosis and a left-sided pontine tumour.

On 3.8.32, however, the cerebrospinal fluid was found to be bright yellow. It contained: Lymphocytes 22 per c.mm.; protein 0.06%; chlorides 0.72%. Sugar present. Wassermann reaction negative.

The patient improved gradually, and on discharge (25.8.32) was able to walk without help. He still had the same physical signs in a minor degree, and his right plantar response was still extensor.

**Hæmochromatosis.**—T. R. ELLIOTT, C.B.E., M.D., F.R.S. (shown by H. P. HIMSWORTH, M.D.).

H. W., male, aged 53, chauffeur.

*History.*—The patient was perfectly well until Christmas 1933, when he was disturbed by the onset of thirst and nocturnal frequency of micturition. From this time onwards he began to feel weak and lost weight rapidly, losing one stone in the next six weeks. His doctor saw him about this time, diagnosed hæmochromatosis, and sent him to hospital. On inquiry it was found that the patient had not noticed his deepening colour, but his wife said that during the last twelve months she had observed that he was gradually becoming darker.

Served in France during the war. No history of any contact with copper. Has always been healthy; no history of any illness other than vague indigestion eight years ago.

One sister, aged 55, developed diabetes mellitus and has recently had an attack of coma. Her colour is said to be normal.

*Present condition, 17.2.34.*—Pigmentation: This is of a brownish blue tint and is most marked on the face, hands and arms; the body is free. The colour is thus distributed on the parts most exposed to light and this is well seen in the sclerotics, where the ellipse normally uncovered by the lids is pigmented whilst the sclerotic under the eyelids is practically normal in colour. There is a patch of pigmentation on the hard palate under the dental plate, but otherwise the skin at the pressure points is normal.

Abdomen: Liver hard; two fingerbreadths down in the mid-clavicular line. Spleen palpable. No signs of portal obstruction. Heart and arteries normal. Blood-pressure 150/85. No abnormalities detected in the lungs, central nervous system or eyes. Fasting blood-sugar 210 mgm./100 c.c.

Urine: Sugar and acetone plus.

The patient is now taking a diet of carbohydrate 150 gm., protein 80 gm., fat 80 gm., and seventeen units of insulin twice a day. He has traces of glycosuria but no acetonuria.

**Xanthoma Diabeticorum.**—T. R. ELLIOTT, C.B.E., M.D., F.R.S. (shown by H. P. HIMSWORTH, M.D.).

P. M., male, aged 19, factory hand.

*History.*—November 1930, began to feel weak and noticed that he was losing weight. At the same time he had a pronounced thirst, and was getting up three or four times in the night to pass water.

He was admitted to a provincial hospital and sent out without insulin on a diet containing little carbohydrate, much fat, and large quantities of green vegetables. Three months after discharge yellow nodules began to appear between the fingers.

Autumn 1931: Admitted to a London hospital and sent out on the same type of diet with 10 units of insulin in the morning and 5 units at night.

Greater quantities of yellow nodules continued to appear and the patient felt far from well.

21.11.33: Attended University College Hospital.

*Present condition* (21.11.33).—Heart, lungs, abdomen, central nervous system, eyes, normal.

*Skin*: Small yellow plaques and nodules in between the fingers and toes. Clumps of button-like nodules on the elbows, and knees and over the ischial tuberosities. Isolated nodules at the back of the neck, on the anterior axillary fold, and in the region of the inner canthus of the eye. The xanthomatous deposits appear to occur, not at points of pressure, but at those places where the skin is most subjected to alternate extension and relaxation.

Blood-cholesterol 590 mgm./100 c.c. Urine, sugar, and acetone, +

*Treatment and course of disease*.—The patient was given a diet composed of carbohydrate 240 gm., protein 60 gm., fat 40 gm., and is taking 15 units of insulin in the morning and 10 units at night.

The lesions remain unchanged, but the patient feels quite well and able to carry on with his work.

17.4.34.—Blood-cholesterol 200 mgm./100 c.c.

### Chloroma.—JULIAN TAYLOR, M.S.

D. D., a girl, aged 15 years and 10 months.

*History*.—Swelling over left eye since December 1933; swelling over right eye since February 1934. No pain is associated with the swellings, but patient has complained of headaches since December 1933. She has lost a little weight since February 1934.

*On examination* (12.3.34).—General pallor of skin and mucous membranes, but no evident wasting. The gums and tonsils appear healthy. In the right orbit there is a smooth, rounded, rubbery swelling projecting downwards from the roof into the upper lid. It extends forward to the supra-orbital ridge which is, however, not involved. The skin over the swelling is dusky in colour and normal in texture. There is no displacement of the eye. In the left orbit there is a similar but larger swelling extending over the supra-orbital ridge into the forehead. The eye is displaced forwards and downwards. There is the scar of a previous biopsy just below the inner end of the eyebrow. The skin over the swelling is a little dusky and the cutaneous veins are a little dilated. There is no ophthalmoplegia or diplopia.

On the vault of the skull there are four bosses. Each is a smooth, rounded, hard boss of about 2 cm. diameter and fixed to the bone; they are not tender. There are two on the left frontal bone and two on the right parietal bone.

There is no gross abnormality of the lymphatic system. There is slight enlargement of the glands in the submaxillary triangles and in the axillæ, but there are no large lymphatic tumours, there is no evidence of nasopharyngeal tumour, and there is no palpable enlargement of spleen or liver.

*Blood-count*.—9.3.34: R.B.C. 3,150,000; Hb. 62%; C.I. 1.0; 130 nucleated red cells per c.mm.; W.B.C. 13,300. *Differential*: Lymphos. 24%; monos. 1%; polys. 30%; myelocytes 15%; myeloblasts 30%.

No Bence-Jones protein in urine. Wassermann reaction negative.

A skiagram of the skull shows increased density of the bone in the left orbital region, the outer part of the roof of the orbit being mainly involved. No changes in the long bones or vertebræ are seen in the skiagram. In the pelvis there is a small area of increased density in the right ischium near the tuberosity, and there is also a localized area of rarefaction in the upper part of the left acetabulum.

An incision into the tumour through the skin over the right eye (14.3.34) under an anæsthetic, revealed a firm mass, of pale olive-green colour, and of uniform rubbery consistence, which bled not at all.

Report on a portion of tumour removed for microscopical examination :—

"The majority of the cells are round or oval with a clear outline. The cytoplasm is scanty and stains well. The nuclei are round, oval or bean-shaped, and stain deeply. Polymorphonuclear cells and eosinophils are present throughout. There

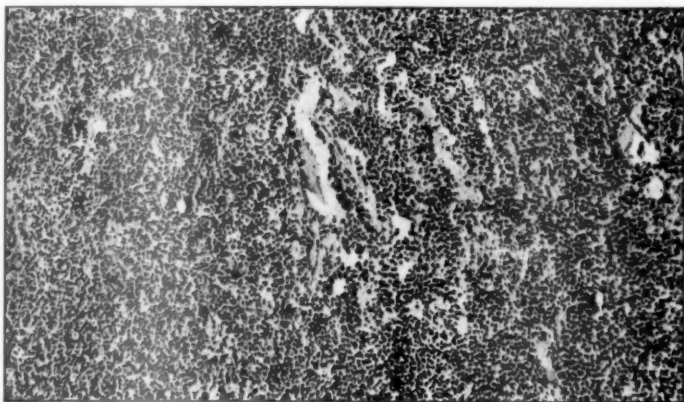


FIG. 1.

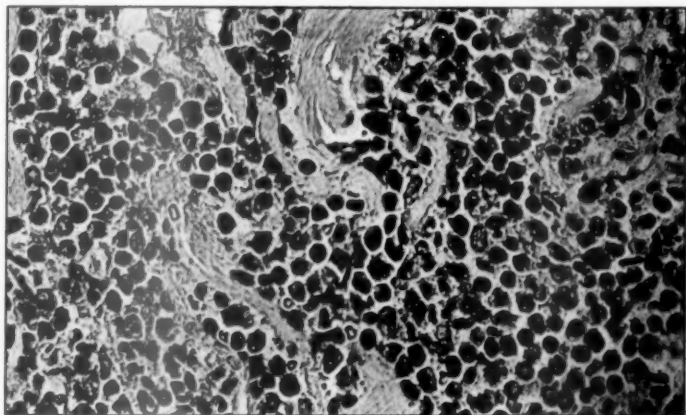


FIG. 2.

are many mitotic figures. The tumour can be seen to be infiltrating striped muscle." (Figs. 1 and 2).

The treatment, so far, has been deep X-ray therapy, directed to the splenic area and to the long bones.

The progress has been irregular. Following the first dose of X-rays, to the spleen, the patient developed severe headache and signs of meningitis. There was

vomiting, the temperature rose to 103° F., and there was marked neck-retraction and a positive Kernig's sign. This condition lasted for about ten days, and then the patient improved and her condition returned to its previous state, and at the moment she is still improving.

On 4.4.34, at the height of the condition of meningism, a number of petechial spots appeared on the face and shoulders.

The left eyeball has gradually become more proptosed and the cornea has sloughed. The proptosis of the right eye, however, is not progressing.

*Blood-counts :*

	9.3.34	21.3.34	29.3.34	12.4.34	16.4.34	21.4.34
R.B.C.	3.15*	3.44*	3.20*	2.97*	3.28*	2.80*
Hb.	62%	70%	65%	61%	64%	60%
C.I.	1.0	1.01	1.01	1.03	0.97	1.07
Nucleated reds	130†	1,500†	1,000†	1,380†	750†	
W.B.C.	13,300†	18,700†	20,700†	22,900†	15,100†	8,200†
Lymphocytes	24%	9%	3%	7%	14%	18%
Monocytes	1%	1%	0%	0%	0%	1%
Polymorphs	30%	24%	36%	21%	30%	49%
Myelocytes	15%	21%	29%	28%	32%	20%
Myeloblasts	30%	45%	32%	44%	22%	12%
Deep X-rays to spleen		26.3.34		12.4.34		
Deep X-rays to right femur					17.4.34	

\* Millions per c.mm.

† Per c.mm.

## Section of Tropical Diseases and Parasitology

President—H. S. STANNUS, M.D.

[March 1, 1934]

### The Bartonella and Related Parasites in Man and Animals (Oroya Fever and Verruga peruviana)

By Dr. WALTER KIKUTH (Elberfeld).

**ABSTRACT.**—Through the investigations of *Noguchi* on the one hand, and *Mayer* and *Kikuth* on the other, the unity of the etiology of Oroya fever and verruga peruviana has been demonstrated experimentally. The *Bartonella bacilliformis*, the causal organism of Oroya fever, belongs to a group of micro-organisms, the parasitic nature of which has been definitely proved during the last few years. Tests with a view to transmitting the disease to monkeys, and the etiology, clinical data, pathology, therapy and immunobiology are further explained with reference to personal experiments.

*Bartonella muris*, which was first observed by *Mayer* in 1921, was confirmed by *Mayer*, *Borchardt* and *Kikuth* to be the causal organism of infectious rat anemia following splenectomy. After splenectomy of the rat, the latent parasite becomes virulent and often causes a fatal anemia. The clinical course of this infection is connected with an endothelial reaction which can be demonstrated histologically. The infection is transmitted by rat lice. Chemotherapeutic experiments led to the discovery of an effective arsenic-antimony compound with an index of 1:3,500, which figure has never hitherto been reached in chemotherapy.

The causal organism of dog anemia following splenectomy is the *Bartonella canis*.

*Bartonella* and bartonella-like structures as causal organisms and harmless blood parasites in various animals.

On account of their peculiar behaviour the *Grahamella*, which were first described by *Graham-Smith*, should be kept strictly apart from the *Bartonella* and looked upon as a species by itself.

**RÉSUMÉ.**—L'identité de l'étiologie de la fièvre d'Oroya et de la verruga peruviana a été démontrée expérimentalement par les recherches de *Noguchi* d'une part et de *Mayer* et *Kikuth* de l'autre. *Bartonella bacilliformis*, l'agent étiologique de la fièvre d'Oroya, appartient au groupe de micro-organismes dont la nature parasitique a été définitivement prouvée pendant ces dernières années. Des essais de transmission au singe, l'étiologie, la clinique, la pathologie, la thérapie et l'immuno-biologie sont décrites en plus de détail en connection avec des recherches personnelles.

*Bartonella muris*, observée d'abord par *Mayer* en 1921, a été confirmée comme agent étiologique de l'anémie infectieuse des rats consécutive à la splénectomie. Après la splénectomie chez le rat, le parasite latent devient virulent, et cause souvent une anémie mortelle. Le cours clinique de cette infection se relie à une réaction endothéliale capable d'être démontrée histologiquement. L'infection est transmise par les pous des rats. Des essais de chimiothérapie ont mené à la découverte d'un composé d'arsenic et d'antimoine avec un index de 1:3,500, chiffre qui n'avait encore jamais été obtenu dans la chimiothérapie.

L'agent étiologique de l'anémie des chiens consécutive à la splénectomie est la *Bartonella canis*.

Description de la *Bartonella* et des organismes qui lui ressemblent comme agents étiologiques et comme parasites innocents du sang chez divers animaux.

En vue de sa conduite particulière, la *Grahamella*, décrite pour la première fois par *Graham-Smith*, doit être séparée absolument de la *Bartonella*, et considérée comme espèce individuelle.

ZUSAMMENFASSUNG.—Durch die Untersuchungen von *Noguchi* einerseits und *Mayer* und *Kikuth* andererseits ist die Einheit der Aetiologie des Oroyafiebers und der Verruga peruviana experimentell bewiesen worden. Die *Bartonella bacilliformis*, der Erreger des Oroyafiebers, gehört zu einer Gruppe von Mikroorganismen, deren Parasitennatur in den letzten Jahren sichergestellt werden konnte. Uebertragungsversuche auf Affen, sowie Aetiologie, Klinik, Pathologie, Therapie und Immunbiologie werden an Hand von eigenen Versuchen näher erörtert.

Die *Bartonella muris*, von Mayer 1921 zuerst beobachtet und benannt, wurde von *Mayer*, *Borchardt* und *Kikuth* als der Erreger der nach Milzextirpation auftretenden infektiösen Rattenanämie festgestellt. Der latente Parasit wird nach Entmilzung der Ratten virulent und verursacht eine oft tödliche Anämie. Der klinische Verlauf dieser Infektion ist mit einer histologisch nachweisbaren Endothelreaktion verknüpft. Chemo-therapeutische Versuche führten zur Auffindung eines wirksamen Arsen-Antimonpräparates mit einem Index von 1 : 3,500, wie er bisher in der Chemotherapie völlig unbekannt ist.

Der Erreger einer nach Milzextirpation auftretenden Hundeanämie ist die *Bartonella canis*.

Bartonellen und bartonellenähnliche Gebilde als Krankheitserreger und harmlose Blutschmarotzer in den verschiedenen Tieren.

Die Grahamellen, zuerst von Graham-Smith beschrieben, sind durch besonderes Verhalten als eine Gattung für sich von den Bartonellen abzutrennen.

THE *Bartonella* form a group of micro-organisms, the parasitic nature of which has been recognized with certainty only during the last few years. It must, however, be left to further research work to classify them into a system of micro-organisms. Although morphologically they have a great similarity to the bacteria, there are many reasons why they should be treated as a separate group of parasites. In human Oroya fever, a malignant affection occurring in Peru, they have been known for a long time as inclusions in the erythrocytes. In the animal kingdom they now appear to be more widespread as causal organisms and apparently harmless blood parasites than was hitherto assumed.

During the last few years the study in this field has been extraordinarily extended and many articles on the subject have appeared in all parts of the world. Although, in the main, an agreement has been reached by all research-workers, in actual details the findings and views differ from each other and are even contradictory. Within the scope of this paper it is impossible to give a conclusive picture embodying all the points or to enter into any detailed account of all that has been written on the subject. I shall confine myself to a rough outline of actual facts, considering in the first place only those experiences which have been firmly established. In co-operation with my esteemed teacher, Professor Mayer, I have carried out extensive experiments in the laboratory and have thus been able to collect valuable experiences in this field, and it is the result of these which I shall make my main theme.

Oroya fever and verruga peruviana, in which *Bartonella* were first observed, are two stages of the same infectious disease. This infection occurs in definitely demarcated districts of Peru and is characterized by two completely differing symptom-complexes. The two stages of the disease generally occur at different times and may then give the impression that two distinct diseases are concerned. This conception is particularly favoured by the fact that in many cases one or other symptom-complex is absent or only slightly evident. The conception regarding the unity of these disease-complexes was based on extensive observations and experiences of Peruvian physicians, but was opposed for a long time by the dual theory which held that they had nothing to do with each other. In 1913 an American Educational Council under the leadership of Strong believed themselves to be in a position to prove the dual ætiology experimentally. It was, however, rejected by the Peruvian physicians, Arce and Monge. Thus the differences of opinion continued and neither one nor the other party emerged from the battle victoriously. It was only in 1926

that Noguchi—and also, independently, Mayer and myself—succeeded in proving experimentally the ætiological unity of both affections.

The clinical aspect of the disease is generally well known. In Oroya fever the most characteristic feature is an intensive progressive anæmia which sets in with the fever. This feature has not been observed in any other disease apart from severe cases of blackwater fever. In very severe cases the number of erythrocytes may fall to one million or even less within a few days. The hæmoglobin content decreases, but the index always remains above one.

The destruction of the blood goes hand-in-hand with an extraordinarily lively regenerative blood formation.

The presence of bacteria-like inclusions in the erythrocytes is even more specific than the occurrence of degenerative and generative anæmia, a fact which was observed by Biffi and Gastiaboru as far back as 1903. The constant presence of these in all patients suffering from Oroya fever led Barton, in 1904, to the conviction that a causal organism of Oroya fever was concerned. By means of dark-ground illumination Strong and his co-workers demonstrated the motility of this structure in the erythrocytes. They believed this to be a definite proof of the parasitic nature of these inclusions. In honour of Barton they called these structures *Bartonella bacilliformis*.

From other quarters, however, their parasitic nature was contested over and over again, and their alleged motility was not considered sufficient proof of it.

In 1926, Noguchi, together with Battistini, succeeded for the first time in cultivating, on semi-solid nutrient media, *Bartonella* from a typical case of Oroya fever. The virus was thus brought from Peru to New York and rhesus monkeys were inoculated with it. In monkeys which had had intradermal inoculations just above the eyebrows characteristic verruga papules developed within a short time. At the same time Noguchi succeeded in cultivating *Bartonella* obtained from the blood of the inoculated monkeys and in maintaining them by passage *in vitro*. Thus he was successful in definitely demonstrating not only the parasitic nature of the *Bartonella* but also the ætiological unity of verruga and Oroya fever.

Almost at the same time, Mayer and I established the same fact in a reverse manner. We excised verruga papules obtained from a patient suffering from verruga peruviana and inoculated them into rhesus monkeys. By continuous animal passage it was not only possible to produce verruga papules in the experimental animals, such as other authors had already accomplished, but in some animals *Bartonella* were found in the blood circulation. Two monkeys died of severe Oroya fever with the characteristic blood picture. Thus we repeated in animals the experiment carried out by the Peruvian student, Carrion, who had inoculated himself with a verruga papule and died of Oroya fever shortly afterwards.

To recapitulate: Noguchi carried out experiments with *Bartonella* which had been obtained from the blood of patients suffering from Oroya fever and produced verruga papules. We commenced our investigations with a verruga papule and produced Oroya fever.

In a Giemsa-stained blood-smear the *Bartonella bacilliformis* may be recognized as bright red, bacteria-like inclusions in the erythrocytes. This applies both to Oroya fever in human beings and to that produced experimentally in monkeys. One finds forms of quite different structure which lie together furnishing an extraordinarily varied picture. In addition to forms like small rods and dumb-bells, there are also round coccus-like structures. The number of *Bartonella* in the erythrocytes varies to a very great extent. In the beginning a few *Bartonella* are encountered only in some isolated erythrocytes; when the infection is at its height and an intense anæmia has set in, large numbers of *Bartonella* are found in almost all the red-blood cells.

Noguchi easily succeeded in cultivating *Bartonella* obtained from the blood of

infected monkeys—even in cases in which *Bartonella* could not be demonstrated microscopically—also from verruga nodules. The cultures were grown on his semi-solid nutrient media for leptospira and on blood-agar even in a dilution of 1 : 10,000. These experiences were confined by de Cunha, Muniz and other authors. Mayer and myself were, however, unable to obtain the culture, although we tried by every possible means to do so.

It was only after Miss Tilden (New York) had been good enough to furnish us with an original culture of the late Noguchi that I succeeded in obtaining subcultures of *Bartonella bacilliformis* without any trouble at all. In experimental infection of monkeys I was able to obtain *Bartonella* with certainty both from the verruga papules and from the blood circulation. I am at a loss to understand to what circumstance this different behaviour should be attributed; I believe, with Noguchi, that the various *Bartonella* strains behave differently in culture.

In Giemsa-stained smear preparations *Bartonella* from cultures appear as bright red structures. On inspection one recognizes at the first glance that they are much smaller than any of the bacteria known to us. It is true that they do not vary so greatly in appearance as the *Bartonella* in the circulating blood: on the other hand they are, however, very similar to them. The dumb-bell forms predominate and the two poles frequently appear to be stained somewhat more strongly. In addition there are also numerous round, coccus-like forms. I should, however, like to draw special attention to the great morphological similarity between the cultural *Bartonella* and the group of the Rickettsia.

Under dark-ground illumination they may be recognized as strongly light-refracting structures. They appear to be somewhat coarser than in the stained preparation. Their motility is very lively and takes place in the whole field of vision.

With *Bartonella* strains placed at our disposal by Noguchi the cultivation of the blood of infected monkeys is very easy and can be effected even in cases of verruga peruviana in which *Bartonella* could not be demonstrated microscopically in the blood. I succeeded in cultivating *Bartonella* from the circulating blood, only if verruga papules were still present. If the papules subsided, or if they had already healed, the culture was always negative. Even a few days after extirpation of the verruga papules it is no longer possible to cultivate *Bartonella* from the blood. It would appear that the verruga papule is the reservoir of the *Bartonella* in the blood circulation. The positive results of cultivation show moreover that even in the slightest cases of verruga a generalization of the virus will take place in the blood.

It is, however, still quite obscure why the inoculation of verruga papules or of the culture of *Bartonella bacilliformis* produces a typical attack of Oroya fever only in isolated cases. It cannot be denied that the virulence of each *Bartonella* strain differs to a very great extent. It is also possible that through passage the virulence of one and the same strain is weakened. On the other hand, consideration should also be given to the fact that a special disposition of the organism is required to bring about an attack of Oroya fever. Based on our findings in *Bartonella* in rats, Mayer and I believe that in Oroya fever also certain defence forces should be ascribed to the spleen. This conception was also favoured by the circumstance that the human cases of Oroya fever are frequently found to be combined with a previous or a chronic malaria infection. In such cases one may assume a certain weakening of the defence forces, especially if through chronic enlargement of the spleen the functional capacity of this organ has been greatly reduced. Through splenic extirpation carried out experimentally in monkeys we were unable to support these hypotheses. In experimental Oroya fever of monkeys it is therefore obvious that the spleen is devoid of any similar protective action such as you may see we were in the habit of encountering in the various *Bartonella* infections.

In experimental verruga the fact is of special interest that it has hitherto not

been possible to produce verruga and Oroya fever clinically through direct inoculation of the blood. The positive experiments emanate either from a culture of *Bartonella* or a verruga papule. It is very probable that all stages of *Bartonella* cannot be transmitted. The *Bartonella* may first have to undergo a certain stage of development in the endothelial cells of the verruga nodules in order to become infectious. In the verruga papules of human beings and monkeys it is practically always possible to find the cell inclusions in the angioblasts, especially if the papule is examined shortly before its final development. These were first described by Mayer, Rocha Lima and Werner. Stained with Giemsa they assume a brick-red colour and are absolutely characteristic of the verruga nodules. This finding was at one time rejected by Strong and his co-workers, but was confirmed by Noguchi, de Cunha and Muniz.

It may be assumed that these inclusions consist of a multitude of very small round bodies which are closely packed together and frequently fill the whole protoplasm of the cell. It is highly probable that they represent developmental stages of *Bartonella*. Sometimes they appear in loose formation especially at the periphery of the cells in question, so that at first sight one may take them for *Bartonella*.

It is, of course, impossible to decide whether these inclusions represent primary stages from which free *Bartonella* develop in the blood or whether, *vice versa*, it is a question of *Bartonella* having penetrated into angioblasts and there increased in this characteristic manner. It is quite possible that in a certain measure these inclusions may be looked upon as reservoirs for the *Bartonella*, which gradually enter the blood and, according to the lack or presence of defence forces, either increase or are destroyed.

The experiences gained by Strong and his co-workers on the one hand, and by Noguchi on the other, in producing an immunity against fresh infection in verruga, I was able to confirm. The immunity has no local limitation, but extends also to non-inoculated areas of the epidermis. These experiences confirm the observations made in human beings in whom, as a rule, a definite immunity remains after the verruga efflorescence has run its course in several eruptions.

Attempts with a view to influencing the verruga eruption through neosalvarsan and other chemical substances have hitherto not proved successful. In Oroya fever experiments in this direction have not yet been carried out. In my opinion there is a much better prospect of chemotherapeutically influencing the *Bartonella* circulating in the blood in Oroya fever than of thus dealing with the *Bartonella* in the verruga nodules. From a practical point of view this should be extremely important, for whereas Oroya fever shows a great mortality, the verruga exanthem represents a harmless affection.

One of the most interesting problems of Oroya fever and verruga is the mechanism of natural transmission. Unfortunately I have no personal experiences in this matter. Townsend was the first to occupy himself with this problem practically; he made a species of *Phlebotomus* responsible as the vector. His thorough entomological studies have unfortunately not had sufficient consideration. His observations have recently been confirmed by Noguchi, Shannon, Tilden and Tyler. Thus the identity of the vector, namely a *Phlebotomus*, appears to be fairly established. The authors assume that *Phlebotomus noguchi* is responsible for transmission.

*Bartonella muris*.—Another *Bartonella* affection which has certain analogies with Oroya fever, but also shows many other symptoms, may be observed in splenectomized rats.

In 1921, in chemotherapeutic experiments on rats infected with trypanosomes, Martin Mayer discovered inclusions in the erythrocytes. On inspection it was found that they bore a great resemblance to the well-known *Bartonella bacilliformis*. Even then Mayer stressed the importance of this finding for the final elucidation of

the parasitic nature of *Bartonella* and suggested for this type the name of *Bartonella muris*.

It had already struck many authors, such as Lepehne, Streuli, Domagk, and others, that in contradistinction to all the other animals and also to human beings, splenectomy is definitely badly tolerated by rats. They become rapidly anæmic and generally succumb. Lauda closely investigated this disease picture in splenectomized rats and felt justified in stating that an infectious anæmia is concerned which runs an acute course and often ends fatally. He designated this disease as pernicious anæmia of rats. In spite of careful microscopic and serological examination he did not succeed in finding any causal organisms.

After having studied the publication by Lauda, Mayer assumed that the *Bartonella muris* previously observed by him would be the causal organism in question. In co-operation with Borchardt and myself he then actually succeeded in demonstrating that in anæmia occurring in splenectomized rats the causal organism is the same as that which he had discovered so far back as 1921.

Our findings have since been confirmed in the widest sense by a large number of authors. *Bartonella muris* is, therefore, a cosmopolitan micro-organism, which under the guise of a latent infection, leads a more or less harmless existence in rats, but becomes a deadly enemy of the organism after the spleen has been removed.

Splenectomy can easily be carried out in rats. A few days after extirpation, generally on the fourth or fifth day, the rats fall ill and become emaciated and under an increasingly intensive destruction of the blood, frequently accompanied by hæmoglobinuria, a large percentage of the animals often succumb within the first fourteen days.

The infection does not, however, always run such a fulminant course but may assume a more chronic character. In some animals definite symptoms may be absent altogether. During the attack of anæmia and after the animal has recovered, a sudden regeneration of blood sets in, and if relapse does not occur, which has frequently been observed to be the case, the animals recover within a short time.

The first *Bartonella* appear in the red blood-corpuscles, although generally only singly, usually forty-eight—and sometimes even twenty-four—hours after splenectomy. In Giemsa-stained preparations they appear as very fine, chromatin-red-stained rods or small dot-like structures. Throughout they are smaller than the forms of *Bartonella bacilliformis*. The anæmia increases in severity in direct ratio to the increase in parasites, and in cases of intensive anæmia the blood is directly inundated.

If only a few parasites are present, no clinical symptoms will occur. In that case an abortive affection will develop, and as no parasites can be demonstrated, one might assume that these animals are still in a healthy condition. In some districts there are, however, species of rats which are free from *Bartonella*.

It was rather difficult to demonstrate the nature of the causal organism of *Bartonella muris*. Our attempts to cultivate *Bartonella muris* on nutrient media and to retain them by passage were unsuccessful.

We finally proved the nature of the parasites in the following manner: We succeeded in transmitting the *Bartonella* to splenectomized hamsters and mice which had recovered from the operation without showing any alteration in their blood. It is true that in these animals no disease analogous to that in rats developed, but large quantities of *Bartonella* could be demonstrated in the peripheral blood for many days afterwards.

Such transmission experiments, unfortunately, could not be extended to rats, because it was found that all rats examined already had a latent *Bartonella* infection. It was not until some time later that experiments in this direction could be carried out by Lauda and Sorge in Italy where a species of rat free from *Bartonella* was discovered.

The protective action of the spleen is of particular interest from an immuno-biological point of view. In trypanosomiasis, piroplasmosis, malaria, and spirochaetosis the protective action of the spleen displays itself as a defence measure of the organism. In none of these, however, is it so pronounced as in *Bartonella* anaemia of rats. To which parts of the spleen this defence rôle is to be ascribed cannot be decided definitely. I am personally of opinion that the conditions here are similar to those in malaria and that the protective mechanism is due to cellular processes, although experiments carried out by Lauda and Flaum, on the one hand, and by Kolpakow, on the other, on parabiotic rats, were in favour of a hormonal protective action of the spleen. Investigations undertaken by Ford, Eliot and myself showed that, as in malaria, so in *Bartonella* infection of rats, no antibodies could be demonstrated either in the blood or in the organs. This result is the more striking if one takes into consideration that under certain circumstances *Bartonella*, even in very severe infection, may disappear with suddenness, i.e. within twenty-four hours. It should, of course, also be borne in mind that the antibodies perhaps circulate in the organism only for a very short time, i.e. a few hours, and may be of a very labile nature.

A finding made by Domagk and myself is in favour of my conception that a cellular process is here concerned. This was that an increase in the number of *Bartonella* in the blood following splenectomy is associated with an endothelial reaction which can be demonstrated histologically. If the endothelial reaction reaches a certain height, the *Bartonella* subside in the blood. The destruction of the *Bartonella* and the power of resistance of the organism appear to increase in proportion to the strength of the endothelial reaction. If rats survive this acute defence reaction after splenectomy, an equilibrium between organism and causal organism is gradually regained, that is to say a latent infection ensues.

At the outset of our studies we were able to convince ourselves of the surprising success obtained with a specific medicinal therapy using organic arsenic compounds, i.e. arsalyt, neosalvarsan and other combinations. The therapy must be looked upon as a "therapia sterilisans magna" in the sense of Paul Ehrlich. Even when strongly diluted, these medicaments were able to cause *Bartonella* suddenly to disappear within twenty-four hours.

If normal rats in the latent stage of infection are treated with neosalvarsan and are splenectomized only after such preliminary treatment, no symptoms will occur. The rats behave just like healthy animals. Thus it was demonstrated that splenectomy is not the cause of the destruction of the rats. Such rats, splenectomized after preliminary neosalvarsan treatment, and therefore remaining perfectly healthy, could subsequently be successfully infected with *Bartonella*. Mayer and other authors also succeeded in obtaining by this procedure stocks of rats free from *Bartonella*.

Later on Uhlenhuth and Seiffert were able to show that combined arsenic-antimony preparations are especially effective. The arsenic-antimony Std. 246 prepared by Hans Schmidt had a chemotherapeutic index of 1:400, whereas that of neosalvarsan is 1:72. On continuing my researches in Elberfeld I found that the arsenic-antimony compound Std. 386 B synthetically prepared by Hans Schmidt had a chemotherapeutic index of 1:3,500, an index which has hitherto been completely unknown in chemotherapy. This finding has also been independently confirmed by Uhlenhuth and Seiffert.

The further question of how *Bartonella* infection develops and whether in this connexion ectoparasites play a part as vectors is also of interest. This question was first tackled by Mayer and he succeeded in irrefutably demonstrating that the lice of rats (*Hematopinus spinulosus*) are the vectors of *Bartonella*. This was also proved independently by the American authors Cannon and McClelland, and was later confirmed by Ford and Eliot in America, and Reitani in Italy.

I may here observe that all the physiological, pathological, immunobiological and hæmatological studies which have been made on splenectomized rats urgently require further confirmation, as one cannot exclude the possibility that such results may have been considerably influenced by a latent *Bartonella* anemia not taken into account by the various authors.

*Eperythrozooa coccoides*.—The *Eperythrozoon coccoides* found in mice is an organism which greatly resembles the *Bartonella muris*. It was discovered independently by Schilling in Berlin, and Dinger in Amsterdam in splenectomized mice. Although this parasite differs from *Bartonella*, both clinically and morphologically, it assuredly belongs to the *Bartonella* group.

From two to four days after splenectomy small bodies appear in the blood of white mice. In a Giemsa-stained blood-smear these bodies generally appear as pale pink rings. In heavy infections the erythrocytes may be completely covered by them. They have a certain predilection for polychromatic red blood-corpuscles. To some extent they prefer the margin of erythrocytes; this, however, may be due to a mechanical cause. In addition to the coccus-like bodies there are also found rod-shaped structures.

The assumption that in the case of eperythrozooa, parasites and not products of degeneration are concerned, is greatly favoured by the following facts: Their successful transmission from diseased to healthy mice as accomplished by Dinger and Schilling; their transmission from mice to splenectomized rats as undertaken by Dinger and myself; and finally, the possibility of influencing the eperythrozooa through neosalvarsan chemotherapeutically.

*Bartonella canis*.—I have also been successful in discovering a further representative of the *Bartonella* group in a splenectomized dog. On the sixth day after splenectomy intracellular structures appeared in the erythrocytes. On the one hand, they had a great similarity to *Bartonella bacilliformis*, and on the other strongly resembled the forms of rat *Bartonella*. On account of their varied shapes and of a few characteristic forms which may be observed they had to be designated as a particular type and were given the name of *Bartonella canis*. My findings have been confirmed by Perrard, and greatly extended by Regendanz and Reichenow.

The course of infection, especially the increase in the *Bartonella*, closely resembles the picture of *Bartonella* anemia in rats; in other respects also a considerable analogy exists. The periodic occurrence and re-disappearance of the parasites in the blood is, however, extraordinarily peculiar and follows a more chronic course.

The parasites multiply up to a certain point, then suddenly disappear from the peripheral blood in a crisis-like manner without any apparent reasons. At the end of a few days—as a rule after four or five—single parasites again make their appearance and then multiply as usual, the process thus repeats itself, and as a whole greatly resembles a recurrent infection. These remissions may be repeated on innumerable occasions and extend over months. There are further interesting details into which I cannot now enter. I may merely remark that neosalvarsan exercises a specific influence on this infection also.

*Bartonella in other animals*.—Various types of *Bartonella* following splenectomy have been described. Thus Nauck found *Bartonella* in splenectomized squirrels; Regendanz and I found them in opossums. *Bartonella* appear to be particularly widely spread in wild rodents (Schwetz and other authors). I should also like to raise the question of whether the *Anaplasma* so widely distributed in the animal kingdom are allied to a certain extent to the *Bartonella*. A number of facts would be in favour of such a relationship. From the point of view of morphology, staining properties, and clinical symptoms there is a great resemblance between these two groups of parasites.

I should also like to draw attention to the peculiar structures in the erythrocytes which Balfour discovered in the experiments he carried out in fowl

spirochaetosis. Their shape is exceedingly variable. The most frequent forms are the ring and flame forms, but coccus—or ball-like—structures have also been observed. Balfour's findings have been confirmed by a large number of authors. Also in cold-blooded animals inclusions could be detected in the erythrocytes. Structures of this kind were described by Doulton, Todd and Tabey in frogs, and by Henry and Tidswell in fish. After having inspected Balfour's smear preparations, Hindle came to the conclusion that here an unknown virus—not related to the spirochaetes—was concerned. It is doubtful whether all these structures do not also belong to the Bartonella group.

*The Grahamella.*—For special reasons the group of Grahamella, although they show a great similarity to the Bartonella, must be looked upon as belonging to a separate genus. The first findings regarding this parasite emanate from Graham-Smith, who in 1903 discovered this structure in the blood of moles which had been caught in the neighbourhood of Cambridge. A year later, these findings were confirmed by Thomson, also in England. A larger number of parasites of the same species have also been very recently found in various rodents and other mammals.

Even from a morphological point of view there exist characteristic differences between the Grahamella and Bartonella. The great variety of forms is lacking in the Grahamella. The Grahamella are much coarser, rod-like structures, which externally rather resemble the bacteria. The size of the single forms varies only to a very slight extent. Even in heavy infections only isolated erythrocytes are affected. One never finds only one or two parasites in an erythrocyte; they are always encountered in quantities of from eight to twenty.

Whereas Giemsa-stained Bartonella assume a bright-red colour, the Grahamella stain more deeply shading into blue (azurophile). It is almost impossible to stain Bartonella with aniline dyes, whereas the Grahamella can be very well recognized.

Splenectomy has not the slightest influence on the Grahamella. In contradistinction to the Bartonella, the Grahamella cannot be influenced medicinally. According to present views, the Grahamella have no pathogenic properties.

For all these reasons the Grahamella and Bartonella must be strictly differentiated from each other, a suggestion which had been already previously made by Mayer and Wenyon.

Finally, I should like to refer briefly to the structures described by von Schilling, the so-called erythrokonten, which he discovered chiefly in cases showing pernicious anaemia, but also in other diseases. It is impossible to decide whether parasites at all are concerned. The same applies to the structures which Schüffner observed in a case of infantile pseudoleukæmia. These structures had been encountered in large numbers in the plasma and within the erythrocytes. Schüffner was fully justified in bringing forward the hypothesis that a parasite of the Bartonella-erythrocyte group already latent in the organism may be activated through avitaminosis.

*Discussion.*—Sir RICKARD CHRISTOPHERS: I suppose that the outstanding feature of interest in Bartonella to many of us—I refer to *Bartonella muris*—is its appearance as an acute infection only after splenectomy and the possible mechanism involved in such a phenomenon. In this connexion there was a paper by Wills and Mehta some little time ago in the *Indian Journal of Medical Research*, noting that rats fed on a diet deficient in A and C vitamins developed severe Bartonella anaemia. Such observations might have a bearing on the mechanism by which invasion by Bartonella is made possible. I should also like to refer to *Bartonella muris* as one of the known haemoglobinuria-producing organisms. Pronounced haemoglobinuria in many of the rats was a feature in the experiments I have referred to and has been described elsewhere in Bartonella infection. Dr. Kikuth has mentioned the enormous red-cell destruction in Bartonella and has said I think, that in no other disease than blackwater fever is the red-cell destruction so rapid and intense.

Dr. C. A. HOARE: We are still in ignorance regarding the true nature of the intracorpuseular organisms dealt with by Dr. Kikuth; their systematic position is so uncertain that it has not even been established whether they belong to the realm of bacteriology or protozoology. At present they are provisionally placed among the Sporozoa, near the Hæmosporidia, as "Protozoa incertæ sedis" or even as "structures of doubtful nature," which include *Rickettsia*, *Anaplasma*, *Grahamia* (= *Grahamella*), *Bartonella* and some other less-known forms. They are probably all of a similar nature, as Dr. Kikuth has stated, and some of them, like *Grahamia* and *Bartonella*, are practically indistinguishable on morphological grounds.

## Section of Urology

President—A. CLIFFORD MORSON, O.B.E., F.R.C.S.

[April 26, 1934]

### DISCUSSION ON ANÆSTHESIA IN URINARY SURGERY

**Dr. H. W. Featherstone.**—Urinary surgery includes operative procedures of all degrees of severity upon patients who vary from the hale and robust to the frail, toxic, or nearly moribund. Furthermore, the kidneys are organs whose state, whether they be healthy or diseased, reacts upon all the functions of the body, and in urology the condition of the kidneys may be affected directly or indirectly by the operation or by the anæsthetic.

With the wide selection of anæsthetic agents and technique which we now have at our command, we should endeavour to avoid those methods which throw an extra burden on the patient and to select the best anæsthetic for a particular case.

I propose, therefore, to review some of the methods and to indicate their special advantages and particular drawbacks.

*Chloroform* still retains its advocates in this as in other branches of surgery. But in addition to the better-known dangers (such as overdose, vagal syncope, heart muscle failure, and extensive degeneration of the liver from delayed chloroform poisoning) attention may be drawn to other risks which are not always recognized. Minor degrees of damage to the liver are probably more common than we realize [1].

Albumin may be found in the urine for a day or two after chloroform anæsthesia in more than 10% of cases [2], and it is reasonable to infer that damage has been caused to the secreting cells of the kidneys.

The blood-pressure changes in chloroform anæsthesia are usually characterized by a fall in the systolic pressure and a rise in the diastolic pressure, with the result that the pulse-pressure during chloroform anæsthesia is reduced. This reduction in the pulse-pressure may interfere, temporarily at least, with the filtration of fluids in the kidneys, and if the kidneys are inefficient there may be secondary disturbances in the body generally.

*Ether* is convenient and good muscular relaxation is readily obtained, but experience shows that in urinary surgery ether may cause damage. The albuminuria which sometimes follows ether anæsthesia indicates that ether is a local irritant to the cells of the kidney tubules, and therefore that it may be harmful in the presence of inflammation of the kidney and in renal tuberculosis. Acute failure of the kidney function following operations for prostatic obstruction appears to be much more common after ether than after other less irritating general anæsthetics. The elderly, toxic, and exhausted type of man, who is frequently seen in urological practice, may go through an operation under ether apparently in safety, but during the period of reaction which sometimes follows ether anæsthesia his condition may fail and he may sink in a few hours. When considering the effects of chloroform and ether, it is necessary to emphasize the important part which the duration of the administration plays in the after-effects. A short anæsthetic which lasts five or ten minutes is associated with saturation of the blood, but comparatively little ether is absorbed by the general tissues of the body. Recovery is rapid, after-effects are mild or absent, and the possibility of harmful effects to the liver and kidneys is not great. On the other hand, if the anæsthetic is administered for more than half an hour, the tissues absorb large quantities of anæsthetic, they eliminate the drug very slowly, recovery is gradual and the kidney and liver cells are subjected to the effects of the drug for many hours. Sometimes one is able to detect the odour of ether in the breath for as long as forty-eight hours after the administration has ended. The employment of carbon dioxide after ether or chloroform appears,

therefore, to be good practice, for thus, by more rapid elimination, the possibility of prolonged action of the anæsthetic drug is reduced.

The changes in the blood-pressure with ether and chloroform affect the amount of the operative hæmorrhage. The low pulse-pressure which is common in the presence of chloroform tends to reduce bleeding; for example the hæmorrhage during suprapubic prostatectomy under chloroform is usually easily controlled, but recurrent hæmorrhage in the post-operative period initiated by the rising pulse-pressure is a very real danger. On the other hand we recall that the usual effects of ether anæsthesia are an initial rise of the systolic pressure followed by a gradual fall; at the same time the diastolic pressure drops quickly and the pulse pressure with ether anæsthesia is greater than the normal. The dilation of the arterioles and the vigorous action of the heart tend to promote free hæmorrhage, which may be troublesome in the course of prostatectomy operations. However, the danger of recurrent hæmorrhage is not great, for the post-operative pulse-pressure following ether is usually small.

*Nitrous oxide* may be required as a short anæsthetic when passing a metal catheter or bougie in an adult, when sounding for stone, or possibly when inserting a Pessor tube. It is perhaps true to say that the *nitrous-oxide-oxygen* mixture as an anæsthetic has scored its greatest triumphs in suprapubic prostatectomy. Usually the blood-pressure is not much affected, nitrous oxide is not injurious to the renal cells, the elimination of the drug is rapid, and after the operation one rarely sees that tendency to prostration which sometimes follows the administration of ether in such cases. By the addition of a small quantity of ether to the gas-oxygen mixture, while at the same time keeping the proportion of oxygen at a high level (at least 20%), cyanosis and congestion are avoided and the heart and vessels are spared from embarrassment. Moreover, a steady rhythm of adequate breathing is more easily maintained, and in practice it is found that satisfactory pre-operative distension of the bladder by water can be easily performed and the rectus abdominis muscles are relaxed sufficiently for careful and deliberate prostatectomy. This small amount of ether certainly bears no comparison with the very much larger doses of full open ether, and the truth of this is demonstrated by the rapid recovery of consciousness at the end of the administration.

*Ethylene-oxygen* produces a somewhat more profound type of anæsthesia than nitrous oxide-oxygen, but ethylene possesses two great drawbacks which have deterred anæsthetists in this country from employing it on the large scale. It has a most unpleasant smell, and the ethylene-oxygen mixture can be detonated at a comparatively low temperature with results which may easily be disastrous. When operating with diathermy machines, it is unsafe to employ mixtures of oxygen and ethylene, or oxygen and ether. In these cases chloroform and oxygen, or nitrous-oxide-oxygen, or local anæsthetic methods are advisable.

Anoxæmia should, of course, always be avoided, but when giving gas-oxygen or ethylene-oxygen to patients whose kidneys are not efficient it should be borne in mind that asphyxia is particularly dangerous, because the activity of the renal cells is reduced to a serious extent by the deprivation of oxygen [3].

*Spinal analgesia* has been employed on an extensive scale in urology, but it is not equally suitable for all cases, and among the wide variety of methods there is ample scope for judgment in choice and for skill in administration. The headache which sometimes follows spinal analgesia may be very distressing. I know of no certain means of preventing it; absolute quietness for forty-eight hours after the operation is, however, a wise prescription.

*Percaine* in its various solutions seems to be standing the test of experience. In the surgery of the upper abdomen, the Howard-Jones method of infiltrating the intrathecal space through the second lumbar interspace with a large quantity of hypobaric percaine solution is particularly effective. The method is valuable in

operations on the kidney when the patient is in the lateral position. The light percaine solution then bathes the anterior and posterior spinal nerve-roots of the side which is uppermost, i.e. the side of the operation. For operations involving the anterior wall of the lower abdomen, the technique involves laying the patient on his face for ten minutes after the injection, a procedure which is very disturbing for elderly and nervous patients. For operations below the level of the umbilicus, I prefer to employ 2.3 c.c. of 1 : 200 percaine solution in normal saline. This is diluted in a 20-c.c. syringe by withdrawing 6 to 8 c.c. of cerebrospinal fluid through a needle in the second lumbar space, and the nearly isobaric solution which is thus formed is reinjected. The patient can then be laid on his back without further disturbance, and analgesia is obtained up to a level just above the umbilicus.

The suprapubic method of prostatectomy has offered a field of great usefulness for spinal analgesia. Nevertheless, certain disadvantages should be borne in mind. Many patients are thoroughly upset by the fact that they are conscious, and, indeed, some of them feel very uncomfortable and ill. If we endeavour to dull the mental impressions, we are faced with the difficulty that most sedatives, whether morphine-scopolamine or a basal narcotic, may throw a load on the liver and the kidneys.

The disturbance of the blood-pressure which occurs under spinal analgesia, especially if the level of analgesia extends above the umbilicus, may be a double source of trouble. First, if the systolic pressure falls, the flow of blood through the glomeruli slows, and urinary secretion is reduced. Indeed, when the systolic pressure is below 40 mm. of mercury the secretion ceases [3]. In urinary surgery this may be a special source of danger, and the collapse which occasionally follows shortly after suprapubic prostatectomy under spinal analgesia may be attributed to the temporary cessation of the flow of urine resulting from the low blood-pressure. Secondly, in elderly patients, normal conditions of the arteries may give rise to trouble. Thus it is not uncommon in urological practice to be called upon to anaesthetize 70-year-old men who are in fair general health, with a systolic pressure of 180 mm., and a diastolic pressure of 110 mm. In such a case, a high spinal anaesthetic might quite possibly reduce the systolic pressure of 130 mm., and the result of this failure of the pulse-pressure would be acute cerebral anaemia and collapse. Cardiologists assure us that a high diastolic pressure requires a high systolic pressure, and that in order to estimate the systolic pressure which is necessary to maintain a satisfactory pulse-pressure we may use the formula  $S = 2D - 20$  [4]. Thus in the example which I have mentioned, as the diastolic pressure was 110 mm., good circulation could only be ensured with a systolic pressure of  $2 \times 110 - 20 = 200$  mm. The need for caution when contemplating the administration of a spinal anaesthetic to a victim of high blood-pressure is clear. It is advisable that a good pulse-pressure should be ensured.

In addition to spinal analgesia, the other methods of local analgesia are specially applicable to urinary surgery. But before entering upon a review of these various methods I would remind you that some patients exhibit marked idiosyncrasy to cocaine and its derivatives, which usually manifests itself immediately after injection, that the addition of adrenalin is important in order to retain the drug in the area into which it has been injected, but that the injection of only 5 minims of adrenalin may produce an unpleasant sensation of cardiac disturbance, and furthermore, that during the subsequent processes of absorption of novocain from the tissues and of its excretion many people feel extremely uncomfortable. There is some justification, therefore, for assuming that the drugs employed in local analgesia have a direct action on the brain, the heart, the liver, and the kidneys. Experimental confirmation of these minor clinical effects is not, however, very satisfactory, for the effects are too small to be measured, and permanent injury is not demonstrable.

The surface anaesthesia of mucous membranes is particularly applicable to the urethra, for catheterization and cystoscopy. Solutions of cocaine are the most effective but they are not trustworthy, as a considerable quantity may be absorbed through a wound or crack in the mucous membrane. I understand that at the Mayo Clinic a 1% solution of cocaine is commonly employed for cystoscopy when there is reason to believe that the mucous membrane is not cracked. Novocain solution is safe and convenient for cystoscopy, but despite its widespread use the analgesia certainly is not always complete. Percaine is more effective than novocain in its action as a surface anaesthetic, but the general view is that cocaine is still the only completely effective agent.

The claim that horocain is a good surface anaesthetic has not received general acceptance [5].

The group of *basal anaesthetics* includes avertin and the newer barbiturates. It should be remembered that these drugs are detoxicated by the liver and excreted by the kidneys. They therefore tend to overload an already embarrassed kidney.

It has been pointed out that many of these drugs have a direct vasodilator effect which leads to an increased flow of blood through the kidney and that would tend to be beneficial to the renal excretory cells [6]. Of the basal narcotics perhaps avertin is the most reliable as an adjuvant with local analgesia.

In conclusion I would suggest that for patients with unsatisfactory blood-pressures and for prostatectomy in patients with inefficient kidneys, perhaps gas-and-oxygen offers the greatest help, but that for extensive and deliberate operations on patients whose kidneys are in fairly good condition, spinal analgesia with a basal anaesthetic may be the method of choice.

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**Mr. E. W. Riches** said that for surface anaesthesia of the urethra he had used 1:500 percaine for more than two years and had found it the most satisfactory of the local anaesthetics. Morphia before cystoscopy inhibited the secretion of urine and caused great delay in the efflux from each kidney, the observation of which was often the most important part of the investigation.

He had used low spinal anaesthesia with 0.4 c.c. of 10% stovaine, as described by Hasler, extensively for endoscopic resection of the prostate, difficult cystoscopies, cystodiathermy, and other urethral and vesical procedures, and found it an admirable anaesthetic. It was quicker and more certain than caudal or trans-sacral block, and produced only about 10 mm. fall of systolic blood-pressure. He did not use it for out-patients.

**Mr. E. T. C. Milligan:** In my experience, low spinal anaesthesia, which is anaesthesia limited to the nerve-supply of the sacral plexus, solves the problem of anaesthesia for all operations and painful manipulations on the penis, perineum and urethra, as well as for intravesical fulgurations and operations through the cystoscope.

The anaesthesia is produced by the intrathecal injection of 0.4 c.c. of 10% solution of stovaine in saline, in the sitting posture, through the third or fourth lumbar interspinous space. While a skilful surgeon can introduce the cystoscope with but little discomfort in most cases, low spinal anaesthesia should unhesitatingly be used

when pain is anticipated by reason of age, build, malady, or nervous temperament. The method is used frequently in out-patient work where, after two hours' rest, sensation returns and the patient can leave. For recurrent papillomata repeated fulgurations under spinal anaesthesia, numbering over twenty, in the same patient, have been carried out with satisfaction in several instances.

The ideal anaesthetic for suprapubic operations has not yet been discovered. Surgeons accustomed to the convenience, efficiency, and ease of operating with spinal anaesthesia, will always feel unhappy with general anaesthesia. At present the choice of anaesthetic for these cases, in the absence of scientific guidance, is a difficult matter. The dangers of circulatory troubles in spinal anaesthesia must be weighed against the well-known drawbacks of general anaesthesia.

This is an occasion for bringing to the notice of the Section the beneficent effects of low spinal anaesthesia in acute painful cystitis seen in its most impressive form in elderly women. No known remedy, whether it be morphia, hyoseyamus, or so-called urinary antiseptic, gives relief. Attempts at bladder lavage increase the suffering and fail to distend the bladder because of its irritable contraction reflex which even a general anaesthetic is powerless to abolish. To increase the fluid intake, as so often advised, merely serves to increase the number of painful micturitions, for the systolic bladder will not tolerate its contents and evacuates, with intense urethral pain, the few drams of urine as they enter the viscus from the kidneys. Relief from pain, happily, can be given by bladder lavage under low spinal anaesthesia which, by blocking the nerve-supply, allows the bladder to distend. It has been the custom to leave in the bladder, after lavage, 20 c.c. of 1:1,500 solution of percaïne, but I am not sure that this is essential. For four or five hours after the treatment the patient is free from pain and sleeps—perhaps the first undisturbed sleep she has had for days or weeks. Bladder lavage under low spinal anaesthesia should be repeated on three successive days if frequency and pain are not at once relieved. After this the bladder distends and is then "washed out" naturally by increased fluid intake by mouth.

Dr. J. K. Hasler said that he agreed with the remarks made by Mr. Riches and Mr. Milligan with regard to the value of low spinal anaesthesia in urinary surgery. The clinical picture of a patient under low spinal anaesthesia was quite different from that of a patient in whom the whole abdomen had been anaesthetized. In the latter case, the patient was often pale and clammy and it was not unusual for a short attack of nausea and vomiting to occur. In the former case there was no loss of the sense of well-being as the fall in blood-pressure was negligible.

He (Dr. Hasler) usually employed 0.4 c.c. of 10% stovaine in saline. Recently he had been using percaïne 1:200 for cases requiring endoscopic resection of the prostate where anaesthesia might be required for a prolonged period. He injected 1.5 c.c. or less of this solution as he found that 2 c.c. might produce anaesthesia up to the umbilicus with fall in blood-pressure.

The absence of fall in blood-pressure with low spinal anaesthesia enabled the surgeon to employ the indigo-carmin renal function test, without delay in the excretion of the dye.

He had tried caudal block anaesthesia but, finding it unreliable, had abandoned it. There was often discomfort during the injection and sensation was not always completely abolished in the perineum. Intrathecal injection, on the other hand, was practically painless and was a much simpler procedure than the combination of caudal and trans-sacral blocks frequently employed in the United States.

He usually ordered omnopon and scopolamine for premedication, to be given an hour and a half before operation.

**Mr. J. Everidge :** For *cystoscopy*.—Novocain (5%) instilled first into the anterior urethra and then into the posterior, with a properly designed tube, is efficient and safe. Correct posture of the patient, i.e. one which allows of complete ease and, consequently, relaxation is an important adjunct to painless cystoscopy. The calves of the legs should be held on well-padded supports not elevated more than 8 in. The crude method of procuring a lithotomy position by supporting the ankles with webbing slings hung from the shepherd's-crook supports of an ordinary operating table, rotates the pelvis backwards, increasing the normal curves of the urethra. Such a position causes discomfort, which aggravates the tendency of the patient to contract the muscles of the thighs and perineum. This increases the difficulty of introducing the cystoscope and causes greater pain.

General anaesthetics depress renal activity, and so render collection of urine by ureteral catheters more difficult.

Gas-oxygen anaesthesia—unless very skilfully administered—possesses the drawback of procuring only imperfect relaxation, and increases the tendency of the bladder to bleed, from capillary engorgement due to partial asphyxia. This is a serious disadvantage in cases of cystitis, especially if tuberculous, and in examination for malignant growths, which already have a great tendency to bleed.

For *suprapubic prostatectomy*.—Spinal anaesthesia has its special indications, notably in certain respiratory affections. Its disadvantages—headaches, ocular palsies, paralytic ileus, fall of blood-pressure—render it, to my mind, unsuitable for routine use. I prefer peripheral block of the nerves supplying the lower segments of the rectus abdominis, which muscle is, after all, the only obstacle in the way of suprapubic prostatectomy. Novocain 0.5% is injected at four points, one on either side opposite the umbilicus, and one on either side half-way down to the symphysis, the needle being introduced near the outer border of the muscle and buried well into its substance. About 5 c.c. are injected at each point; thus the motor nerves are bathed and their activity is suspended. Sufficient general anaesthetic—ether, gas-and-oxygen, or even chloroform—is administered on the mask, to produce unconsciousness and analgesia. The novocain will have given adequate relaxation of the recti.

For *endoscopic prostatic technique*.—A low spinal analgesia with any of the substances mentioned is the method of choice. The small amount required, limited in its distribution and effects by posture, precludes the disadvantages already mentioned. This method simplifies the operative technique by procuring (1) relaxation of the perineal muscles, and (2) a slight fall in blood-pressure, which diminishes bleeding and so renders the major bleeding points more easily seen, when obstructing tissue has been removed by resection or punching.

## Section of Orthopædics

President—ST. J. D. BUXTON, F.R.C.S.

[March 6, 1934]

### Congenital Absence of the Fibula with Associated Deformity of the Femur.—MAURICE LEE, F.R.C.S. (introduced by the President).

Brenda S., aged 2 years. Deformity of left leg noticed since birth. Began to walk at age of 19 months, with peculiar gait.

On examination the left leg is seen to be much shorter than the right. The thigh appears to be normal; the deformity is noticed in the leg and in the foot, which is kept in a valgus position. The left leg is thinner than the right. The tibia can be felt along its whole length, but the fibula cannot be felt at all.

Skiagrams show a left femur which is not only much shorter than the opposite member, but is also deformed at its upper end (fig. 1). In the leg the fibula is seen to be absent (fig. 2). All the bones of the foot appear to be normal.



FIG. 1.



FIG. 2.

*Comment.*—Congenital absence of bones has been mentioned in the journals on numerous occasions. Theories of the cause are:—

(1) The germinal theory; (2) the mechanical theory; (3) the traumatic theory.

The germinal theory assumes a defect in the mesoblast. The cause of this defect has not yet been discovered, but it has been ascribed, without proof, to microbic, toxic and endocrinal influences.

The mechanical theory supposes absence of bones to be caused by external pressure on the foetus (e.g., from intra-uterine malposition), or by amniotic bands or by constrictions caused by the umbilical cord.

According to the traumatic theory the cause is violence sustained by the mother during pregnancy.

The germinal theory is, I believe, the right one, and it is supported by the fact that other defects also are sometimes seen in these cases—e.g. cleft palates.

**An Unusual Dislocating Hip.**—NORMAN CAPENER, F.R.C.S.

The patient, a girl, aged 5½, is attending a school for mentally defective children. She is of somewhat mongolian type, and until a few days before I saw her, no lesion of the locomotor system had been observed. Walking was normal, and the only



FIG. 1.



FIG. 2.

thing that had been noted was that a year previously, while confined to bed with a cold, the child developed a peculiar habit of causing her left hip to click audibly. Since then nothing of further note happened until the end of February, 1934, when,

while the patient was again in bed with a cold, clicking of the hip was once more noticed, and when she suddenly cried out with pain, the nurse-in-charge found that the hip was apparently dislocated. The medical officer (Dr. Micklem), reduced the dislocation with moderate ease. Scarcely had he left the building, however, than the child had again dislocated the joint, and in fact, she dislocated and reduced the joint herself many times during that day and the two days following. Pain occurred only during the actual movement of slipping in and out. I saw the patient and confirmed the observation that the hip did, in fact, dislocate. The patient had no fever and there was no swelling of the hip-joint apart from the deformity produced by the great trochanter when the hip was "out."

Two skiagrams were kindly taken for me by Dr. Wroth, the first (fig. 1) after I had reduced the dislocation, and the second (fig. 2) a minute or so later, after I had redislocated the joint. These skiagrams show that the left acetabulum is not normal, it is somewhat shallower than on the right side and its outline is irregular.

The further course of the case is of interest. My inclination was to fix the pelvis and left lower extremity by plaster in the abducted position for six weeks. I did not do so however, for, a week after my examination, the child was well again; walking freely everywhere without pain or limp, and showing no propensity to continue her peculiar habit. A little later I re-examined her; her hip was apparently normal and I saw no reason to submit her to any fixation. She has continued to walk normally and to be free from pain.

#### Lipoid Granulomatosis with Generalized Osteomalacia.—NORMAN CAPENER, F.R.C.S.

At the recent meeting of the British Orthopædic Association at Edinburgh, Prof. John Frazer included under the term "lipoid granulomatosis" a group of diseases in all of which there is a disturbance of lipid metabolism, manifested by deposition of fatty substances in cells of the reticulo-endothelial system. These disturbances are eponymously termed (1) the Schüller-Christian disease; (2) Gaucher's disease; (3) the Pick-Niemann disease. The morbid histology of each presents a characteristic type of cell common to all—the "foam cell" (fig. 5, p. 33)—which has a "vacuolated" cytoplasm—the "vacuoles" of which, in appropriately stained fresh sections, can be demonstrated to contain lipoids, cholesterol, cerebroside, etc., the nature of each lipid being different in each of the three diseases. The distribution of the granuloma-like infiltration in different organs is responsible for further distinguishing characters in each disease. As the lipid substances approach nearer to the chemical value of ordinary fats, so the tumour masses appear more yellowish in appearance and thus are sometimes called xanthomata.

Isolated xanthomata appear in the ends of long bones and in connexion with tendon sheaths and bursæ. By some writers they are regarded as osteoclastomata related to giant-celled tumours and to osteitis fibrosa cystica.

The present case is one of special interest for, while there was an isolated bone tumour of the xanthoma type, there were, in addition, metabolic disturbances associated with a marked generalized osteomalacia. In fact, before the nature of the tumour was discovered, the case was regarded as one of von Recklinghausen's disease of bone.

A young man, aged 22, was admitted to hospital in April 1930, complaining of pain in the back and in both feet, associated with general weakness and loss of height. Of gradual onset, these symptoms had been present for three years. The principal features found on clinical examination were shortening of the trunk, so that the lower ribs rested within the pelvis, prominence of the sternum, and a general kyphosis of the dorsal spine, which was also somewhat tender. Both hips presented mild flexion deformity and some limitation of abduction and internal rotation. There was pronation of both feet, with severe tenderness between each scaphoid bone. During

the investigation of the case a swelling was discovered at the lower end of the left thigh; this swelling, though painless, had been noticed by the patient for eight years previously and had not increased in size. Clinically, it was an apparent enlargement of the whole circumference of the lower portion of the diaphysis of the femur. No limitation of function was found in the neighbouring knee-joint.

Radiographic examination showed extensive decalcification of the skeleton; this was most marked in the spine (fig. 1), which presented the changes seen in osteomalacia. Associated with the loss of lime salts, there was compression of many of the vertebral bodies, with apparent increased thickness and cushioning of the intervertebral discs. The upper ends of the femora presented some degree of epiphyseal coxa vara (fig. 2). Many of the other metaphyses also showed deficiency of bone formation (fig. 3).

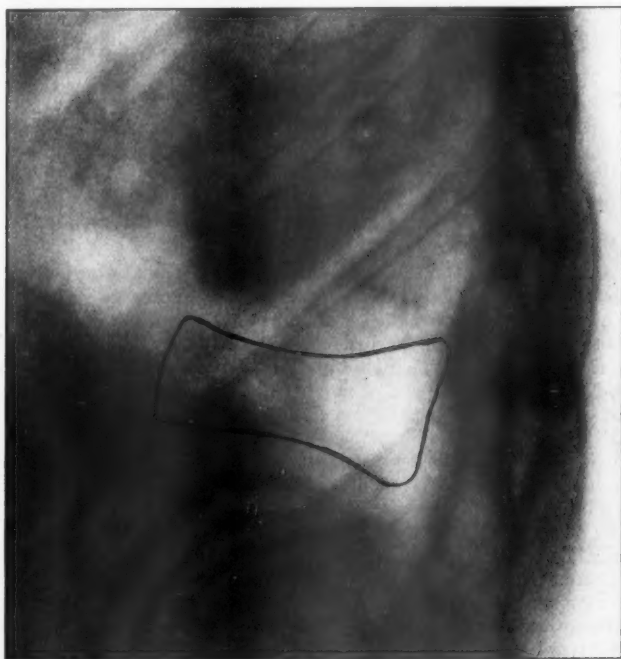


FIG. 1.

The swelling of the lower end of the left femur (fig. 4) was fusiform and "osteocystic" in appearance.

The diagnosis of osteitis fibrosa cystica with generalized osteomalacia was made. In view of the radiological signs of osteomalacia and the "cystic" bone tumour, the possibility of hyperparathyroidism was considered; no clinical evidence of parathyroid tumour was found, however, and the blood chemistry was normal.

Biopsy of the tumour of the left femur was performed and after a window of thin cortex had been lifted, the femoral cavity was found to be filled with yellow fibrocystic tissue, small spicules of bone and quantities of darker pigmented material, suggestive of old hæmorrhages (much of the tissue, in the gross, resembled

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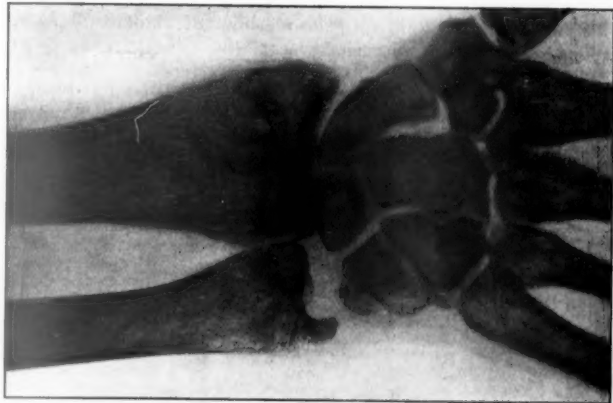


FIG. 3.



FIG. 2.

rather overcooked scrambled eggs with streaks of chocolate). A naked-eye diagnosis of xanthoma was made. This was confirmed on histological examination (fig. 5).

After the operation a more detailed study of the calcium tide was carried out by Dr. Thomas Finlay, following the methods of Bauer and Aub. The total metabolic changes for an eight-day period were:—

	Urine	Feces	Total	Intake	Balance
gm. Ca.	0.6489	2.0864	2.7353	1.5231	- 1.2122
gm. P.	3.1995	1.5705	4.7700	5.4278	+ 0.6578

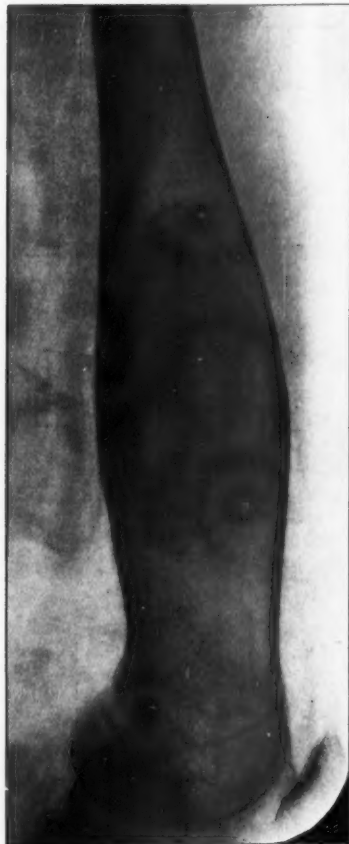


FIG. 4A.

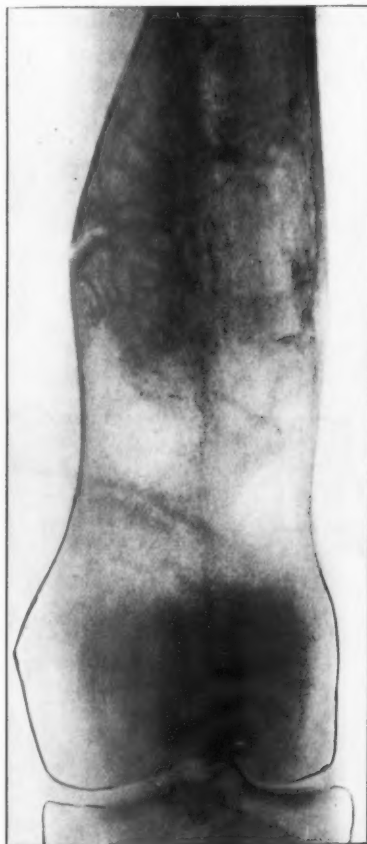


FIG. 4B.

suggesting that the patient had been undergoing demineralization in small amounts for a very long time. As there was no excess of urinary calcium, the possibility of hyperparathyroidism at the time of the examination appeared to be eliminated.

A second operation was performed upon the tumour of the left femur, at which the entire contents of the fusiform enlargement were evacuated, as though the condition were one of giant-celled tumour. This was followed by deep X-ray therapy and medical treatment by calcium and vitamin D in large doses.

The patient made excellent progress and a letter from him in February 1932, stated that he was well and back again at full work as a farm labourer.

*Comment.*—The important question is whether this case belongs to the group of diseases of lipid metabolism or whether it is a case primarily of disturbed calcium metabolism, as in hyperparathyroidism, with a local osteoclastoma of the xanthoma type. The association of decalcification of the skeleton with a fatty tumour must, however, be of more than accidental significance and one would like

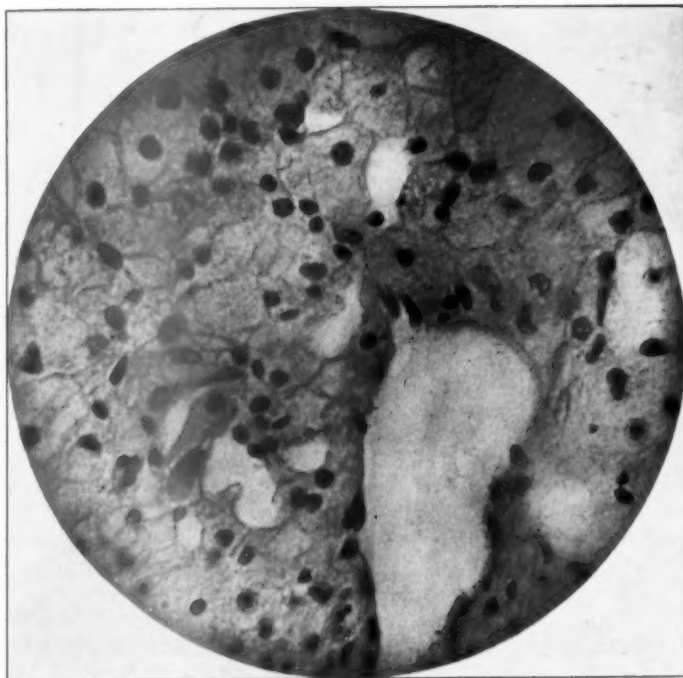


FIG. 5.

to offer the suggestion of a possible relationship between the two, comparable to that found in the epiphyseal deformities associated with idiopathic steatorrhœa. Unfortunately in this case no data are available upon the question of fat excretion, though the blood cholesterol was normal.

I am indebted to Dr. Thomas Finlay of the Department of Internal Medicine of the University of Michigan for the biochemical investigations and for much other assistance in the case.

#### **Ununited Fracture of the Humerus with Ossification of the Flexor Muscles of the Forearm.**—B. H. BURNS, F.R.C.S.

A. B., male, aged 55. The patient is unable to give a clear history of his disability, but states that he sustained the fracture of the lower end of the humerus in (?) 1914. He went to a hospital but apparently did not avail himself of the opportunity of treatment. He has had considerable disability in the limb since then.

*On examination.*—Ununited fracture of lower end of humerus. The hand is held flexed, owing to contracture of muscles of the forearm; very slight movement in the direction of extension is possible; the hand is practically useless. There is no evidence of involvement of any of the nerves.



A skiagram shows an ununited fracture three inches above the lower end of the humerus, with overlap. There is ossification in the muscles of the flexor aspect.

Is it possible that the patient had a Volkmann's ischæmic contracture and that ossification has taken place in the fibrosed muscles?

**Arthritis of Hip following Traumatic Dislocation.**—B. H. BURNS, F.R.C.S.

J. E., male, aged 29, dislocated his hip three years ago. The dislocation was reduced immediately, without difficulty, under a general anæsthetic. The hip gave no trouble until six months ago when it began to be painful. The pain is not very severe and does not keep the patient awake at night. He walks with a slight limp.

All movements are somewhat restricted. Abduction is not possible beyond the straight.

A skiagram shows deformity with sclerosis of the head of the femur. It is thought that these changes are the result of damage to the blood supply.

**Myositis Ossificans of Shoulder.**—S. ALAN S. MALKIN, F.R.C.S.ED.

H. L., male, aged 51. When first seen March 27, 1933, complained of pain and stiffness in the right shoulder. He stated that at the end of December 1932, he had fallen off a cart and injured his head. A week after the accident he noticed stiffness of his shoulder.

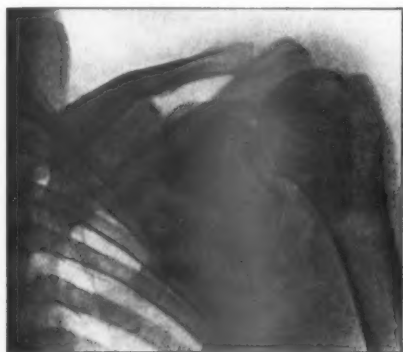


FIG. 1.—Myositis ossificans of shoulder. 3.1.33.  
(approximately two weeks after accident.)



FIG. 2.—26.2.34.

*On examination.*—Swelling and tenderness of the shoulder with wasting of muscles. There was apparently no movement in the shoulder, which was held adducted (fig. 1). Movement gradually returned, and on February 26, 1934, the arm could be passively abducted  $60^{\circ}$  with  $20^{\circ}$  movement in the shoulder-joint (fig. 2).

PROFESSOR D. T. HARRIS read a short paper on **Calcification and Ossification of the Semilunar Cartilages.**

The following cases were shown :—

(1) **Milroy's Disease.** (2) **Genu Valgum following a Fracture of the External Tuberosity of the Tibia.**—A. H. TODD, M.S.

(1) **Scurvy.** (2) **Clicking Knee.**—A. ROCYN JONES, F.R.C.S.

(1) ? **Tuberculous Hip.** (2) **Injury to the Lower Epiphysis of the Tibia.**—S. A. S. MALKIN, F.R.C.S.ED.

**Bilateral Tuberculous Hip.**—E. LLOYD, F.R.C.S.

**Charcot's Hip.**—B. WHITCHURCH HOWELL, F.R.C.S.

[May 1, 1934]

**Two Cases of Congenital Kyphosis.**—E. LAMING EVANS, C.B.E., F.R.C.S.

(1) J. W., aged 5 years, has a slight kyphosis involving the eighth, ninth, and tenth dorsal vertebræ. This was first observed in August 1930. It has been treated by a Whitman's frame and has not increased (fig. 1).

A lateral skiagram shows that the normal bodies of the eighth, ninth, and tenth dorsal vertebræ are absent, these bodies being represented by a semilunar-shaped centre completely detached from the neural arches (fig. 2, p. 36).

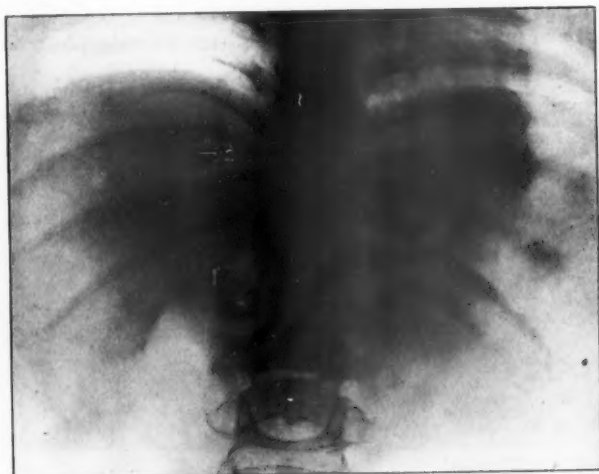


FIG. 1.



FIG. 2.

(II) M. P., aged 10 years, has a kypho-scoliosis involving the ninth, tenth and eleventh dorsal vertebræ. The kyphotic curve is severe and more marked than the lateral curve, which involves the right side. The deformity was noticed in infancy

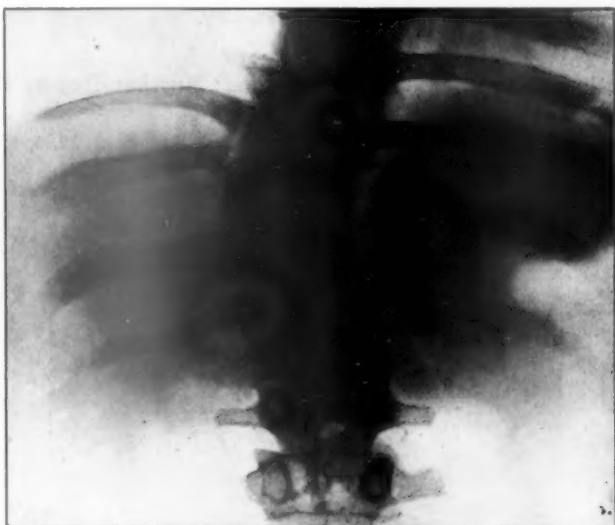


FIG. 1.



FIG. 2.

and has not been treated. An antero-posterior skiagram (fig. 1, p. 37) shows that the left half of the tenth dorsal vertebra and the left rib are absent.

A lateral skiagram (fig. 2) shows that the fronts of the bodies of the ninth and eleventh dorsal vertebrae are separated only by an intervertebral disc and that half of the tenth vertebra has been displaced laterally.

**Calcification of the Semilunar Cartilages: Further Report on a Case Previously Shown.**—G. R. GIRDLESTONE, F.R.C.S.

S. B., aged 46, shown November 7, 1933.<sup>1</sup> On January 2, 1934, I excised the whole of the internal and external semilunar cartilages from the right knee, through anterior and posterior incisions on each side. Removal was difficult, as the cartilages were very firmly attached and harder than normal.



Calcification of the semilunar cartilages.

When last seen the knee was strong and the patient was back on light duty, but there was still a liability to some accumulation of fluid. The creaking had entirely disappeared.

The skiagram of the cartilages taken after their removal shows the calcification.

**Congenital Absence of Ulna with Associated Deformity of Radius.**—MAURICE LEE, F.R.C.S. (introduced by the President).

The patient is a boy aged 5 years. On clinical examination, absence of the lower two-thirds of the ulna is noticed. In addition, dislocation of the radius at the elbow-joint is felt posteriorly to the lower end of the humerus. The function of the limb is perfect.

This case is of interest mainly because of the prognosis. It is obvious that the radius will continue growing upwards behind the humerus.

<sup>1</sup> *Proceedings*, 1934, xxvii, 572 (Sect. Orthop., 14').

The treatment at present, we all agree, is to advise no surgical interference, but I feel that, ultimately, something will have to be done. The simplest operation would be merely to remove the upper end of the radius.



It has been suggested that, in addition, the deficiency in the lower end of the ulna should be made up by means of a bone graft. Whether this would make much difference is a matter of opinion.

**Two Cases of Albers-Schönberg Disease.**—MAJOR-GENERAL J. W. WEST, C.M.G., C.B.E., R.A.M.C. (introduced by Mr. Fairbank).

(I) Private Ball, aged 24, Essex Regiment.

*Previous history.*—No serious illness.

*Family history.*—Good. Father dead. Mother, four brothers and three sisters alive and well.

Patient is a healthy, athletic young man, who plays football and boxes. Nothing abnormal discovered on ordinary clinical examination.

Recently he sustained a slight injury to his shoulder and an X-ray examination showed marked areas of sclerosis in the head of humerus and scapula (fig. 1, p. 40). Other bones showed similar changes (fig. 2).

Skiagrams of the skull show that the sella turcica is small and that the clinoid processes appear to bridge it over (fig. 3, p. 41).

Estimation of blood calcium and phosphorus shows a diminution, blood calcium being 0.5 mgm. per 100 ml. of blood, compared with the normal 10 mgm., and phosphorus—as inorganic phosphate—1.5 mgm. per 100 ml. of blood, compared with 3 to 4.5.

From the military standpoint it is important to decide if this patient is more liable to fracture of bones than a normal man is. He is an athlete, and if he sustains a fracture while playing in an organized game the State is likely to have to pay a pension for the rest of his life.



FIG. 1.



FIG. 2.

It is generally considered that deposits of calcium salts do not make for strength in a bone depending on the lamellar structure which is lost in these densely calcified areas.

Mr. Fairbank, who has seen some of the skiagrams, considers that this condition is not true "marble bone" but more closely resembles that which has been described as "osteopathia condensans disseminata" in which the liability to fracture is not so marked as in Albers-Schönberg disease.

Skiagrams are also shown from another similar case occurring at the same station some months ago. The patient has been invalided out of the Army and in that case, unfortunately, no skiagrams of the sella turcica were obtained.



FIG. 3.—Shows sella turcica bridged over by bone.

The condition of "osteopathia condensans disseminata" is not given in the official nomenclature of diseases or referred to in any of the standard textbooks.

For Army purposes the case must be diagnosed as one of Albers-Schönberg disease.

(II) (Skiagrams only) Private Woodward, P. W. V., aged 21.

*History.*—No previous diseases of note. Had always enjoyed good health and lived a robust life, playing football and other vigorous games. Had never had any fracture.

Admitted to hospital with a recent injury to the left knee. Stated that he had twisted the knee whilst playing football.

Clinically there were typical signs of a dislocated external cartilage—tenderness, history of locking, and a clicking on flexion and extension of joint.

Routine X-ray examination of the left knee, October 20, 1933, showed signs of



FIG. 4.



FIG. 5.

Albers-Schönberg disease of the bones (fig. 4). Skiagrams were taken on the same day of both wrists and hands, and showed the disease in all the bones (fig. 5).

November 16, 1933. Skiagrams of the pelvis and left ankle and foot were taken showing involvement of all the bones.

*Blood-count.*—R.B.C. 5,530,000; C.I. 0.9. Blood calcium 11.5 mgm. %. W.B.C. 7,200. *Differential:* Polys. 49%; lymphos. 47%; large monos. 3%; basos. 1%.

Patient has been invalided out of the Service as a case of Albers-Schönberg disease, owing to the special liability to fracture.

The following cases were also shown :—

**Conical Stump of Arm with its Artificial Limb.**—ST. J. D. BUXTON, F.R.C.S.

**Disease of Upper Cervical Spine.**—R. BROOKE, F.R.C.S.

**Congenital Deformity of Forearm.**—D. McCRAE AITKEN, F.R.C.S.ED.

**(1) Agenesis of Femora. (2) Lobster Hand.**—KENNETH HERITAGE, F.R.C.S. (introduced by Mr. B. H. Burns).



## Section of Laryngology

President—MUSGRAVE WOODMAN, M.S.

[May 4, 1934]

**Aphonia of Forty-four Years' Duration caused by Inhalation of a Stud, requiring Tracheotomy: Voice reproduced during Digital Compression of Sides of Larynx.**—Sir JAMES DUNDAS-GRANT.

Middle-aged man whose voice had been reduced to a whisper since childhood, when he accidentally inhaled a collar-stud. Tracheotomy had to be hurriedly performed, and the stud is stated to have been then extracted through the mouth, although it was broken in the process. The voice now is a mere whisper. The tip of the upper part of the thyroid cartilage is bent to the right, or at any rate there is an extremely deep depression behind it. The laryngoscope reveals imperfect adduction of the right cord, and beneath it a pale projecting swelling, the inward projection of the thyroid cartilage corresponding to the deep depression behind the tip. On inspiration the right cord sinks in below the ventricular band. When the sides of the larynx are compressed with the finger and thumb on special spots the voice is loud and fairly clear. I am endeavouring to get a spring-truss to go round the back of the neck with pads to press on these spots.

POSTSCRIPT.—On further examination I found that the anterior tip of the thyroid cartilage pointed to the right with, consequently, a depression behind it on the same side and a comparative bulging behind it on the opposite one. When I pressed this tip to the left with my right thumb and at the same time exercised pressure with my right index or middle finger on the left-sided bulging, the voice became loud and distinct.

(The patient can now (July 1934) make himself heard when he calls "to his youngster upstairs," compressing the thyroid cartilage as described.)

In the laryngoscopic picture there was what seemed to be a pale smooth bulging under the anterior part of the right cord shelving off below the left cord. I interpret this bulging as corresponding to the depression behind the tip of the thyroid cartilage preventing the apposition of the anterior part of both cords.

**Hyperkeratosis or Pachydermia Laryngis associated with Unusual Bacterial Concretions around Ectopic Epithelial Cells in the Submucous Coat. Inspiratory Stridor.**—Sir JAMES DUNDAS-GRANT and W. E. CARNEGIE DICKSON.

Male, aged 52. Complained of hoarseness and difficulty in breathing keeping him awake at night. When seen in consultation on March 5, nodular pachydermoid swellings were found on both vocal processes and in the interarytenoid space. The vocal cords were extremely œdematous, and often indrawn during inspiration, causing the dyspnoëic attacks. The condition was thought to be pachydermia and not carcinoma, and a few days later J. D.-G. nipped the growth off the left vocal process, together with a portion of the œdematous surface tissue of the vocal cord.

The difficulty in breathing was at once relieved and there were no further attacks of nocturnal dyspnoea. The voice is still rather husky. In 1923, the patient had had a somewhat similar experience.

There was then (in 1923) extreme cedematous swelling of the left vocal cord. J. D.-G. grasped it with forceps but did not extract it. A week later there remained only a circumscribed rounded projection which J. D.-G. extracted with Whistler's forceps. The tissue was not examined microscopically but was most probably inflammatory. There is possibly some relation of this episode to the ectopic development of squamous epithelial cells described below by W. E. C. D. The patient is much in the midst of dust and emanations from japanning processes and has had to use his voice excessively.

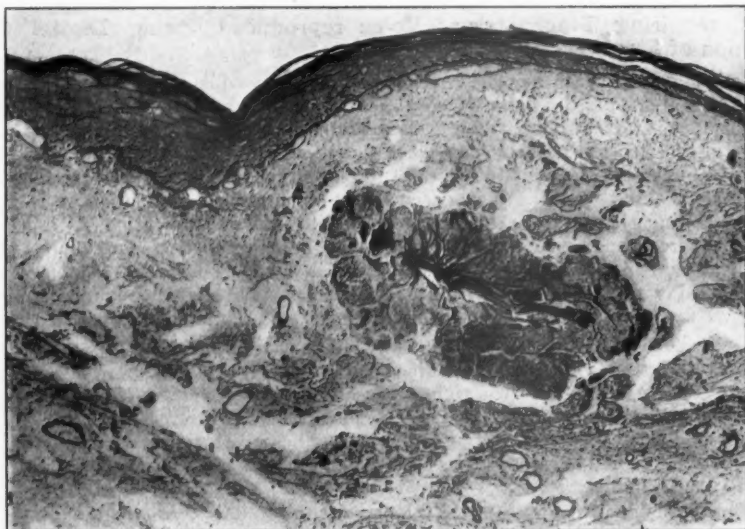


FIG. 1.—Low-power view of a section of the largest of the "bacterial concretions" around a central core of ectopic surface squamous epithelial cells, which, in the original section, are stained an intense red colour identical with that of the superficial cells of the stratum corneum—both showing as black in the micro-photograph—while the surrounding delicate connective tissue of the submucous coat is stained blue. Note that there is no cellular inflammatory reaction round this concretion, and that the surface squamous epithelium immediately over it is thinned rather than thickened, though there is some chronic irritative thickening just peripheral to it (towards the left side). The masses of bacteria of which the concretion is mainly composed are only faintly stained by this method and are better shown in fig. 2. (Mallory's acid fuchsin, aniline blue, Orange-G. stain for connective tissue.) ( $\times 100$ .)

*Pathological report* (W. E. Carnegie Dickson).—The histological findings were unusual. In the submucous coat there are what may be described as several old bacterial concretions around a central core of ectopic surface squamous epithelial cells, the micro-organisms present being chiefly Gram-positive cocci, both staphyloid and in short streptococcal chains, and, in some parts, Gram-positive leptothrix filaments such as are common in tonsillar concretions. (Figs. 1 and 2.) An interesting point is that there is no recent acute or

subacute inflammatory reaction around these concretions—only a comparatively minor degree of fibrosis in their neighbourhood, over which there is old hyperkeratosis of the surface epithelium with some surface œdematous swelling. The

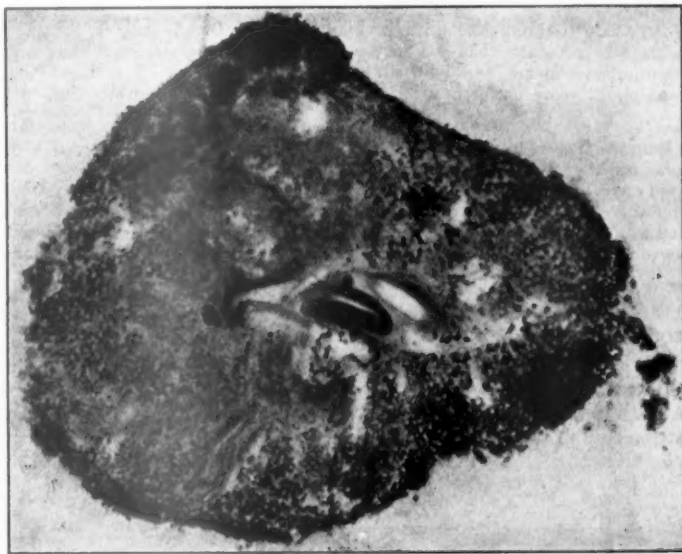


FIG. 2.—An oil-immersion micro-photograph of another portion of the same concretion, stained by Gram's method for organisms. In this particular area they are chiefly Gram-positive micrococci, both staphyloid and in short streptococcal chains, though elsewhere leptothrix-filaments (such as are common in tonsillar concretions) were also found. (Gram's method.) ( $\times 1300$ .)

ectopic surface epithelial cells and bacteria have evidently been carried in a long time previously, and the tissues of the submucous coat having become accustomed to their presence, any inflammatory reaction has long ago passed off.

*Discussion.*—P. WATSON-WILLIAMS said he wondered whether this might be a case in which the infection was of nasal origin. The patient had had nasal and post-nasal catarrh for years, and there were symptoms which one would expect to find with a chronic infective condition of the nose. He (the speaker) once had a case of chondritis tuberosa in a clergyman which proved very intractable to treatment, but when he examined the nasal sinuses he found a definite source of infection there, and after this nasal sinus infection had been eradicated, the larynx cleared spontaneously. He suggested that in this case the condition of the nose should be investigated; it might explain why the patient had a recurring infection in the larynx. More often such infection was seen in the pharynx.

W. E. CARNEGIE DICKSON, said that he had not previously encountered this condition in the mucous membrane of the larynx. The lesions were multiple. There was some surface epithelial thickening at the periphery but not directly over the concretions. Special staining methods were used to demonstrate that the core consisted of squamous epithelium, the remainder of the concretions consisting of an enormous mass of Gram-positive cocci. The centre of the concretion showed the ectopic cells. The epithelial thickening seen was what Sir James Dundas-Grant had diagnosed as pachydermia. There were also some leptothrix organisms, such as were sometimes found in tonsillar secretions. These organisms had evidently become practically non-virulent but, as an area of focal sepsis, constituted a potential source of septic absorption and danger to the patient.

W. S. THACKER NEVILLE asked why, if the cells indicated were ectopic epithelial cells, they should not be called malignant? And why could not giant cells be demonstrated if the lesion was due to a foreign body?

The PRESIDENT asked whether the bacteria found were of low malignancy or not.

SIR JAMES DUNDAS-GRANT (in reply) agreed with Dr. Watson-Williams that some nasal trouble was present. The patient's work was in a dusty atmosphere, largely metallic from chromium and nickel, and he used his voice a good deal. A re-development of the pachydermia might prove dangerous. He would again examine the nasal sinuses.

W. E. CARNEGIE DICKSON (in reply) said the ectopic cells and organisms could be carried in from the surface by injury, operation, or old disease. It was *not* malignant disease, as there was no active or metaplastic growth of cells; cells had merely been displaced or transplanted and had survived in the new position. There was now only very slight inflammatory reaction. The organisms had been there a long time and the tissues had become accustomed to their presence. He could not find any trace of neoplastic formation.

In answer to the President, the bacteria present were probably now practically non-virulent.

#### Restoration of Depressed Nose by Grafting of Cartilage: Six Cases.—A. H. MCINDOE.

##### *Group 1.—Hinged Cartilage Graft.*

I.—A. C., male, aged 40, ex-R.A.F. Aeroplane accident in 1919, with depressed fracture of nasal bones and loss of cartilaginous septum. Cartilage graft inserted at that time but result indifferent. First seen October 26, 1933. Pro-



CASE I.

nounced saddle deformity of nose. Nasal bones flattened, septum absent. Small piece of grafted cartilage lying over the nasal bones insufficient to restore the bridge. Operation November 15, 1933: Previous graft removed and hinged cartilage graft, cut from the right seventh rib, inserted through columellar transfixion incision.

II.—R. B., male, aged 17. Football accident, when aged 12, resulting in suppurating hæmatoma of septum, and complete loss of cartilaginous support. First seen October 6, 1933. Typical saddle deformity of nose. Complete absence of septum, and marked widening of alar bases. Operation October 10, 1933: Massive hinged cartilage graft cut from the seventh costal cartilage and inserted through columellar transfixion incision.



CASE II.

III.—F. S., female, aged 17. Fell over iron fence, when aged 7, and fractured nose. Three weeks later suppurating hæmatoma of septum drained. Subsequently nose became flattened. First seen June 28, 1933. Extreme degree of flattening of

bridge, and tilting of tip of nose. Operation June 29, 1933: Hinged cartilage graft cut from right seventh costal cartilage, and inserted through columellar transfixion incision.

In these three cases the hinged graft was used because support for the tip was required. Elevation of the tip of the nose materially diminishes the amount of widening of the alar bases, and adds to the attractiveness of the result.



CASE III.

*Group 2.—Straight Cartilage Graft.*

IV.—C. S., male, aged 54. Three months previously motor accident resulting in an extreme degree of facial deformity, and multiple fractures of the facial bones and lower jaw. First seen December 20, 1932. Multiple operations for facial restoration, including rhinoplasty by forehead flap. The support for the new nose

was obtained by inserting a massive straight cartilage graft cut from the right seventh costal cartilage. In this instance the straight graft was used because of the complete absence of septal mucous membrane in which the supporting piece might have been embedded.



CASE IV.—Straight cartilage graft to nose after rhinoplasty.

*Group 3.—Septal Cartilage Graft.*

V.—G. B., male, aged 24. Broken nose, aged 6, followed by operation for nasal obstruction. Since then gradual increase of nasal crookedness. First seen September 14, 1933. Marked degree of deflection of the nose, first to the right and then to the left. Dislocation of the cartilaginous from the bony septum. The crookedness of the nose was entirely due to the deflected septum, the nasal bones

being straight. It was decided that the best result would be obtained by removing the deflected septum and utilizing it in modified form to restore the bridge line. Operation September 21, 1933: In conjunction with Mr. D. R. Wheeler, I removed the entire septum, with the exception of a small supporting piece along the



CASE V.—Septal cartilage graft to nose after submucous resection.

anterior border, designed to support the tip of the nose. A straight cartilage graft was then prepared from the removed septum and inserted through a separate incision beneath the bridge. This method of regrafting cartilage following submucous resection has proved extremely valuable in extreme degrees of cartilaginous crookedness.

*Group 4.—Osteochondral Graft.*

VI.—W. C., male, aged 9. Twelve months previously struck on nose by cricket bat, resulting in depressed fracture of nasal bones and hematoma of septum. First seen January 19, 1934. Nasal bones flattened, septal cartilage absent, typical saddle deformity. Operation April 13, 1934: Osteochondral graft removed from right seventh rib. This consisted of 1 in. of rib including the costochondral junction removed subperiosteally, and split longitudinally. The bony portion was splayed out to form the new nasal bones, while the cartilage took the place of the missing septum. It was inserted through a split columellar incision after suitable undermining of the soft tissues of the bridge. This type of graft is useful in children as it probably increases in size *pari passu* with the child.

*Discussion.*—The PRESIDENT said that in the previous week he had performed one of these operations, and was impressed by the good access to the roof of the nose. It was easy to put in the graft when a full exposure had been made. He wondered why bone had been used in the cases demonstrated, in addition to cartilage, and whether whole cartilage would not have done as well. He also wondered whether the bone always lived when it was so placed in position. If not, infection would be a serious matter. The incision used in these cases was a great improvement over the old one. Had Mr. McIndoe any suggestions for the repair of small perforations in the septum, which were a source of trouble after operation?

W. E. CARNEGIE DICKSON said he would like to know more about the survival of the cartilage grafts, as cartilage was a non-vascular tissue. Was it because of that fact that it survived? Was it because it obtained its nourishment by a process of diffusion or osmosis from outside? He would expect bone to form a mere scaffolding, and then undergo gradual absorption.

W. S. THACKER NEVILLE said he had used this type of graft for syphilitic cases, and much improvement had followed. The removal of cartilage subperichondrially rendered the operation easier. When performing these operations he had punctured the intercostal artery, and on one occasion the internal mammary. The incision now described would enable the surgeon to avoid these pitfalls.

W. J. HARRISON said that, though not actually germane to the subject, he would like to mention one point. When carrying out submucous resection he always removed as large a piece of cartilage as he could and put it into warm saline solution. It was not always possible to avoid tearing the mucous membrane on both sides. Should this happen, he placed a piece of cartilage between the two flaps at the site of the perforations.

BEDFORD RUSSELL said that he had had some experience in the use of cartilage grafts at the hospital at Sidcup, and was aware of some of the difficulties. He had been particularly impressed by Mr. McIndoe's remark about making a nose out of a bald head; that statement would be appreciated by anyone who had seen hair growing on a flap much more profusely than it had done when the tissue grafted was in its original site. Even if one chose sites which were practically hairless, one could sometimes see it producing practically a beard in its new situation.

With regard to the remark that the boy had lost support for the bridge of his nose, and that therefore it had dipped following septic hæmatoma, the speaker would rather put it that the bridge had been pulled in by scar-tissue. He did not think that much support was needed for the bridge of the nose; and if the nasal bones and alar cartilages were present, the nose stood up well, unless scar-tissue was exerting traction.

J. F. O'MALLEY said that during the War he had seen some cases with subsidence of the nose, and some that were the result of submucous resections of twenty-five years previously.

He inserted two separate pieces, one running under the bridge, the other into the columella. He had not treated any cases by the method now described, which seemed to show an excellent approach, and gave opportunity to use a larger piece of cartilage.

E. A. PETERS said that if a cartilage graft was inserted over a mass of fibrous tissue, firm union resulted. Many years ago, in a case of gunshot wound of the jaw, in which there was fibrous union, he had performed a subcutaneous operation and inserted a cartilage graft over the fibrous union. Within three months there was comparatively firm union, and the patient was able to masticate.

A. H. MCINDOE said that the incision depended on the type of graft. A hinged graft required a large exposure. The knife was introduced through the membranous septum and then turned forward, and brought straight out through the base of the columella. The columella was then separated from the septum to the tip of the nose and lifted by a small hook. For a straight cartilage graft he used a split columellar incision, and for the septal cartilage graft either a split columellar incision or a small incision inside the nose at the junction of the ala with the columella. Lifting the columella from its base was found to give adequate exposure and practically no visible scar after resuture. One removed about 3 inches of costal cartilage completely and divided it longitudinally into two portions. One portion was used as a graft and the other was put back as a spare beneath the skin in case of accident to the first piece. The shape of the graft was modified according to the type of the depression and the size of the nose, but in general consisted of a bridge-piece to support the bridge and a columellar piece intended to rest against the nasal spine and connected to the bridge piece by a perichondrial hinge. The remainder of the graft was entirely denuded of perichondrium.

In reply to Mr. Carnegie Dickson's question of bone versus cartilage, he (the speaker) had used bone for some cases, but as this had been removed from the crest of the ilium, it might not be considered to be entirely bone, since it contained a considerable amount of dense fibrous tissue and some cartilage. He believed that a bone graft such as would be obtained from the tibia would gradually be absorbed from its lower free end. There was evidence to show that a bone graft did not remain as such, but was gradually replaced by a process of creeping substitution and hence in a few years time it was not the same bone that was inserted. This occurred provided the graft obtained bony union at both ends. Hence a straight bone graft to the nose consisting only of bone would be gradually absorbed from the lower end upwards. Another difficulty with regard to bone was the troublesome shaping and manipulation.

There was no question of the survival of cartilage grafts; they did not tend to be absorbed but remained *in situ*. If for any reason one was obliged to remove a cartilage graft, it was

found to be in practically the same condition as when it was inserted. Presumably it was nourished by lymph.

With regard to perforations of the septum, he (the speaker) had had very little experience; but he believed that if a small perforation could not be closed by a plastic-flap operation from the surrounding mucous membrane, the best treatment would be to make the perforation bigger, as it was found that the bigger the hole the less trouble it gave.

In reply to Mr. Thacker Neville, he would point out that only an osteochondral graft was removed subperiosteally as it was so close to the pleura that there was some danger of opening the pleura during removal. At the costochondral junction the periosteum and the pleura were very adherent. In removing the ordinary costal cartilage sufficient length was stripped of its muscles and removed with the perichondrium intact. There was no danger provided one did not go too deeply.

In reply to Mr. Bedford Russell, he thought that the dose of X-rays required to epilate a piece of skin would so damage the surrounding epithelial cells as to decrease their vitality seriously. He had found that skin grafts removed from other portions of the body and used on the face, frequently showed a profuse growth of hair within a short time. This was probably due to the fact that when apparently hairless skin was shifted to a part of the body where it was free from the friction of clothes hair was able to grow.

#### **Papillomata of the Nasal Mucosa.**—EDWARD W. BAIN.

Male patient showing numerous papillomata in left side of nose. Similar case exhibited in December 1911.<sup>1</sup>

*Discussion.*—HERBERT TILLEY said he doubted that this was a case of simple papilloma; it looked more like a congested granulomatous mass on a broad base. He advised that a substantial portion should be removed and carefully examined by a pathologist. If the growth proved to be malignant the whole septum should be removed.

T. B. JOHNSON said that a year ago he had had a case almost identical with this. He had first dissected off the growth, under the idea that it was a bleeding polypus of the septum. It returned, and he then diathermized the remains. It again returned, and he then put some radon seeds around the site. Since then the case had progressed favourably. The Pathological Department reported that the growth was of low-grade malignancy.

W. STUART-LOW said that he had had two similar, though less extensive, cases. After getting the nose clean and aseptic he began to take off pieces fairly freely, and then, the bleeding being stopped by pressure, he rubbed the papilloma with a nitrate-of-silver stick, after which the condition cleared up and there had been no recurrence.

BEDFORD RUSSELL said that he had seen two such cases, one in a man, and the other in a woman. Both were treated with radium, and the condition disappeared and did not recur. He did not know why radium removed these growths, because papillomata, especially laryngeal ones, had an infective factor.

E. W. BAIN (in reply) said that when he had shown the similar case in 1911, he had believed the condition to be very rare, but most of the members then present seemed to have seen several cases of it. He did not think, however, that another case of the kind had been shown since then. The former case was also shown by the late Mr. Hunter Tod in 1914, and then the growth had invaded the antrum on the same side. It seemed to be malignant, but Professor Turnbull, who had examined sections from it, thought it was only on the way to becoming malignant. Professor Stewart, who had examined sections from the growth in the present case, reported that it was a typical squamous-celled papilloma, but at one point there were appearances suggestive of commencing carcinomatous change. If any operation was performed, it must be an extensive one, as the growth covered practically the whole septum on that side, and involved the inferior turbinal.

#### **Right Frontal Sinus Suppuration with Orbital Abscess. Abscess of Left Frontal Lobe producing Bilateral Visual Defects. Operation. Recovery with Partial Blindness.**—L. GRAHAM BROWN.

Male, aged 18, referred September 14, 1933, by Dr. Gordon Holmes as a case of abscess of the frontal lobe, following suppuration of the right frontal sinus.

*Previous history.*—December 1932: Enucleation of tonsils and submucous resection of septum at another hospital. June 1933: Onset of symptoms of suppuration

<sup>1</sup> Proceedings, 1912, v. Sect. Laryng. 53.

of the right frontal sinus, complicated by an abscess of the right orbit. An ophthalmologist incised and drained the orbital abscess. July 13: Patient complained of headache, and two days later vomiting occurred. The right frontal sinus was thereupon opened and drained through the original incision in the upper eyelid, a large quantity of pus being evacuated. Intermittent vomiting occurred until July 19, and after this operation the patient for the first time noticed dimness of vision. He saw only the lower half of the visual field in the right eye, and there was an enlarged blind spot in the left eye. September 14: On admission, examination showed a healed scar above the inner canthus of the right eye. The nasal fossæ appeared to be normal, and there were no other symptoms beyond the loss of vision previously stated. The patient was observed for a week and further examinations were undertaken. Skiagrams showed only a slight density of the right frontal sinus. The blood-count gave an increase of white cells (12,400), and examination of the cerebrospinal fluid showed a cell count of 6 per c.mm. (lymphocytes).

*Ophthalmological report.* (Mr. W. H. McMullen.) Right eye: Loss of the upper half of the visual field. Marked papilloedema, disc margins blurred particularly in upper nasal part. Left eye: An enlarged blind-spot in the visual field. Papilloedema, disc margins obscured.

September 21: At a first operation the anterior and posterior walls of the right frontal sinus were removed. It was then noticed that, since the sinus was large and overlapped the middle line, the left frontal lobe also came into relation with it. Moreover the appearance of the dura suggested that the path of infection to the brain was towards the left frontal lobe. At a second operation a week later a large abscess was found in the left frontal lobe, although this was not located until after the right lobe had also been explored. Tube drainage was carried out, and the wound partially closed. The pus grew a pure culture of *Staphylococcus aureus*. Recovery from the operation was uneventful, and the wound completely healed in three weeks. However, at the last examination of the visual fields, on February 21, 1934, only slight improvement of the eyes was recorded.

There are several points of interest in this case. One is the comparative mildness of the symptoms of the frontal lobe abscess, particularly after the initial recovery from the sinus and orbital symptoms. Another is the rarity of contralateral brain abscess following frontal sinus suppuration; this is due to the fact that the right frontal sinus overlapped the mid-line towards the left frontal area. As for the eye lesions, we have here peculiar bi'lateral effects. In the right eye there was horizontal hemianopia, in the left a central scotoma.

I was careful not to disturb the overlying meninges, though the right frontal lobe was explored before I found the abscess in the left lobe.

My method of drainage was simply to insert a rubber tube, split at the outer end, and kept open with a safety-pin. No doubt recovery was largely due to the fact that there was a single abscess, not multilocular, and that I was able to avoid infection of meninges.

W. E. CARNEGIE DICKSON suggested that the remarkable success in this case might have been due, in part at all events, to the fact that the organism was a staphylococcus. When the organism was the *Streptococcus pyogenes*, the result was much more likely to be fatal, from a meningeal spread.

## Two Specimens: Abscess in Frontal Lobe of Brain. Sinus Suppuration.—E. D. D. DAVIS.

### *I. Following chronic frontal sinus suppuration.*

Male, aged 20, received a blow on the forehead, followed a month later by an abscess over the supra-orbital margin. Abscess opened, but patient gradually became drowsy. On one occasion he probed the sinus himself, and suddenly felt something give and experienced pain. He may have thus perforated the inner wall

of the frontal sinus. When admitted to hospital there were sinuses over the orbit. Upper eyelid swollen. Patient drowsy and unable to calculate simple addition sums. Speech slow and hesitating. Severe headache. Right eye showed optic neuritis.

Superficial abscess and frontal sinus opened and found full of pus and necrosed bone. Considerable improvement followed. Eight days later headache and drowsiness returned. Purposeless movement of limbs. Brain abscess opened and drained. The patient died four days later.

## *II. Large abscess in left frontal lobe, due to foreign body in the nose.*

Male, aged 17. Admitted on account of headache and coma. He had had three fits, two before a fall, one since; did not bite tongue or pass water; experienced an aura, i.e. shivering, some short time before onset. Five years ago he fell on to a curb, striking the right temple; lost consciousness, but, except for pain where struck, he was soon well. Three months later, complained of headache, not very severe, lasting two or three days. During last four weeks memory failed, headaches became more frequent, of longer duration, and more severe; during last two weeks continuous headache with giddiness, and patient had been kept in bed.

*On admission:* retention of urine; catheterized; large amount drawn off. Eyes: Both discs and surrounding fundus congested, outer margin of left, and the upper and inner margin of right disc ill-defined, no actual swelling. Veins much enlarged. ? Early optic neuritis. Pupils both react normally. Knee-jerks increased on left side, normal on right. Back of neck stiff and slightly painful. Drowsy; became more comatose; unable to swallow; fed by tube. Incontinence of urine. Knee-jerks diminished, then absent. Optic neuritis and a small right corneal ulcer developed. Later, ankle clonus and Babinski's sign developed on left side, absent on right. Temperature throughout normal or just subnormal, except during the last three days, when it rose to  $101^{\circ}$ . Cheyne-Stokes respiration developed a short time before death. No nasal symptoms.

At the post-mortem examination a slate-pencil was found passing through the antero-internal portion of the orbital plate in the region of the anterior ethmoidal cells. The pencil had penetrated for 2 centimetres from the nasal into the anterior fossa of the skull, and was firmly fixed. The dura was not perforated and there was no extradural suppuration, but there was a large intracerebral abscess in the frontal lobe. It was not known how long the slate pencil had been in the nose.

The brain showed externally a patch of firmly adherent dura mater, and just to the left of the mesial fissure, in front of the olfactory bulb a slightly depressed area covered by thickened opaque pia-arachnoid, which lay in contact with the slate pencil. The smooth appearance of the cortex from compression of convolutions was well shown. The cut surface showed considerable enlargement of the left frontal lobe, which contained an abscess cavity 4.5 by 5 centimetres, of irregular shape and partly enclosed by a fibrous capsule, surrounded by infiltrated cedematous brain substance. The contents were thick foul pus and necrotic brain substance, some of which adhered to the wall. Towards the left, a recent extension of the pathological process has occurred, where a considerable amount of brain substance is seen in various stages of necrosis. The lateral ventricle is greatly compressed, the anterior horn being practically obliterated.

*Microscopically.*—The wall consists of necrotic white matter infiltrated with inflammatory round cells. Both specimens are shown with the object of illustrating the difficulties of drainage of a brain abscess.

The first specimen (Plate I) shows the damage done by a drainage tube introduced into the brain. It is presumed that the pulsation of the brain has displaced the tube and made it useless. At the operation there was no doubt that the drainage tube was introduced into the abscess cavity and stitched to the scalp. The operation

PLATE I

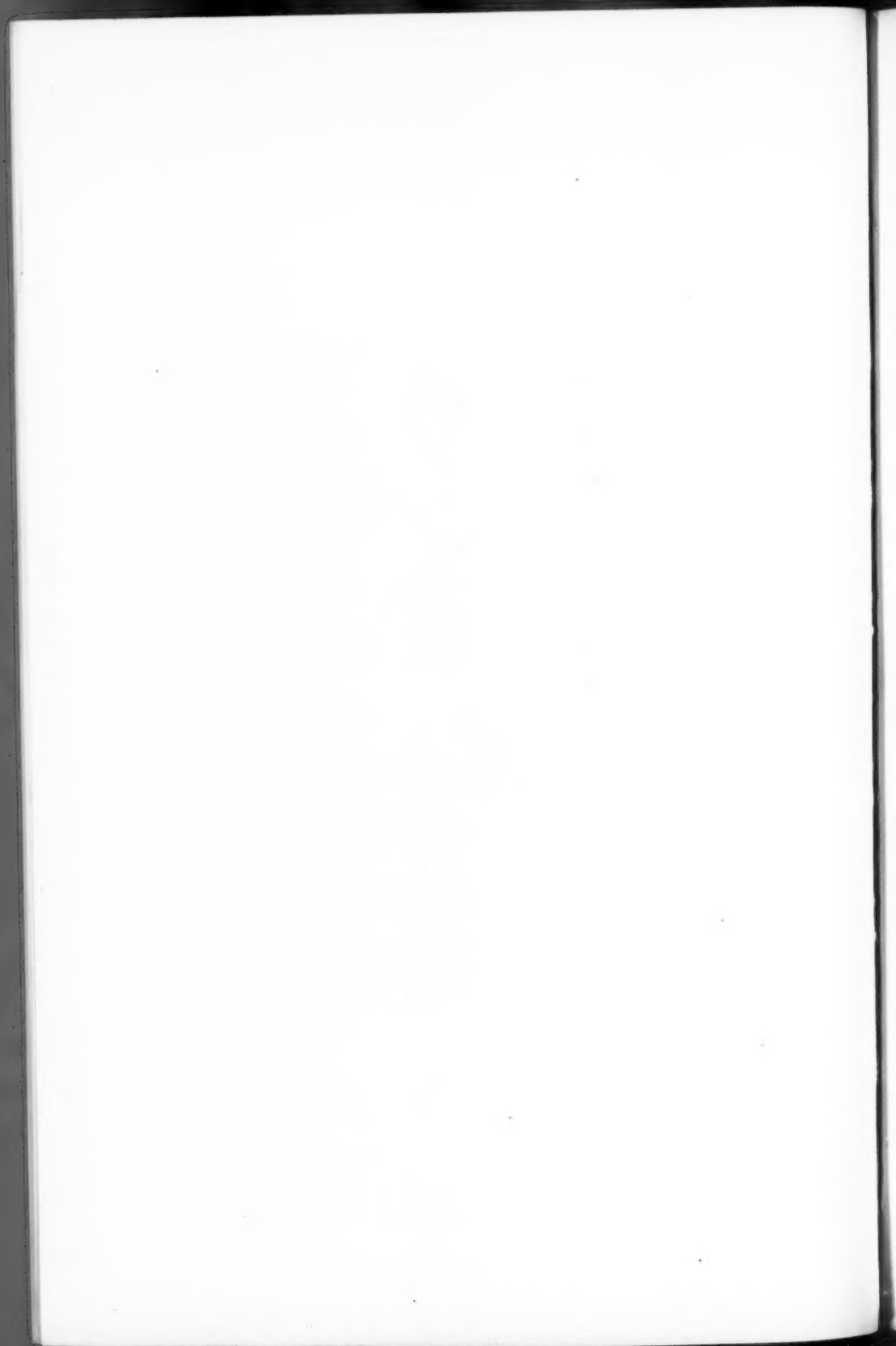


John Ross Scott & Tinsley, 114, London

Multiple abscesses in the frontal lobe of the brain, secondary to frontal sinus  
suppuration (Charing Cross Hospital Museum).

*DAVIS: Two Specimens: Abscess in Frontal Lobe of Brain. Sinus Suppuration.*





was done by an experienced surgeon who had been a house surgeon to Sir William Macewen.

During the War it was soon discovered that if a drainage tube was inserted into the brain nearly all the patients died of meningitis or encephalitis commencing about the fifth or sixth day. On the other hand, if the wound was thoroughly cleaned, and if all foreign bodies and debris were removed and the wound closed without drainage, 52 % recovered. If a brain abscess is carefully cleaned of all sloughs by gentle irrigation with normal saline or Ringer's solution, through an aural speculum or a two-way catheter in which all fluid is allowed to escape freely, a drainage tube or similar appliance does more harm than good, and this is particularly true of an acute abscess. Drainage tubes of any kind, or gauze wicks, should be avoided whenever possible. It is better to risk a second operation than to insert a drainage tube. Whatever type of drainage is adopted, no pus escapes through the tube after the first few hours. The fact that so many different types of appliance for drainage have been tried indicates that none of them is satisfactory. The pressure of the drainage tube damages the tissues, and sooner or later a secondary infection is inevitable. A gauze drain or packing is worse than a drainage tube.

The treatment of a *chronic* abscess must be more thorough, but the operation can be so designed as to make the insertion of tubes and such appliances unnecessary. I have never had the good fortune to see a chronic brain abscess which could be enucleated like a tumour. Sir William Macewen, whose success in the treatment of brain abscesses forty years ago has not yet been equalled, avoided drainage tubes in cases of acute abscesses. In his book he strongly emphasizes the importance of thoroughly cleaning out all the sloughs by irrigation and evacuating the abscess as completely as possible. His operations were designed to avoid drainage tubes. It is true that in chronic abscesses of long duration he reluctantly inserted decalcified bone tubes which were quickly softened and absorbed. The dressing was also left undisturbed as long as possible, even for two or three weeks.

These remarks concerning the drainage of brain abscesses can be applied with greater confidence to abscess in the neck. If such abscesses are completely opened, drainage tubes are unnecessary and the scarring is considerably reduced. No one ever attempts to insert any type of drainage appliance into a retropharyngeal abscess, with the result that the healing of a retropharyngeal abscess after free incision is a matter of hours. The success of the acute mastoid operation depends on the opening of every suppurating cell and not on the introduction of drainage tubes. It is the unopened suppurating cell and not the absence of a drainage tube which leads to trouble.

I have been present at no less than four discussions on the treatment of abscesses of the brain, and each time the discussion has been mainly as to what material or type of tube should be used for drainage or, incidentally, as to whether the brain should be explored with the finger when a trocar fails to find pus.

The question is how can a drainage tube be avoided and not what type of appliance should be used. If such an appliance cannot be avoided, then a double tube is the most satisfactory, but I am convinced that greater success can be obtained by discarding such appliances for drainage. It is important to know if anyone has seen a case in which failure could be definitely attributed to the absence of a drainage tube, or to the too early removal of the tube. Multiple abscesses, as in this case, are frequent, or another abscess develops later. Such a condition can only be detected by an encephaloscope, such as an aural speculum, or by gentle exploration with the finger.

The illustration of the second specimen (Plate II) shows a large frontal lobe abscess resulting from a sharp slate pencil which had been accidentally forced through the roof of the nose into the anterior fossa of the skull. The patient was comatose when

admitted to hospital, and in consequence the history of how the accident happened is unknown, but it is probable that the slate pencil was driven through the roof of the nose during a fall five years before death. The pencil had passed through the anterior ethmoid cells and the roof of the lateral mass of the ethmoid, and projected for 2 cm. into the anterior fossa of the skull. The pencil must have penetrated the dura and so caused the abscess, but at the necropsy the dura mater had healed and there was no extradural abscess. It is extraordinary that the patient had survived this injury more than a few days. When the roof of the ethmoid has been accidentally perforated during a nasal operation the patient has died within a few days from a basal meningitis.

The extensive œdema and enlargement of the whole of the cerebral hemisphere is an indication that the compression should be relieved by removing as large an area of bone as possible. A large opening in the skull allows the meninges to bulge into the aperture and this helps to shut off the subarachnoid space; in addition, sufficient room is obtained for gentle manipulation and for drainage to be established at the most desirable point.

**Specimen: Lymphangioma of the Oesophagus.**—E. WATSON-WILLIAMS.

Male, aged 61, complains of aching pain in the chest in the region of the lower portion of the sternum during two months, and vomiting (i.e. regurgitation of unaltered food) during the same period. Pain may occur at any time, even at night, and is not connected with taking food; he can take fluids fairly well, but all solids are rejected. No loss of weight; no palpable glandular or other swelling. A barium bolus shows considerable dilatation of the œsophagus—which is slightly tortuous to the right—and apparently complete arrest of the bolus immediately above the diaphragm; the outline of the obstruction is irregular.

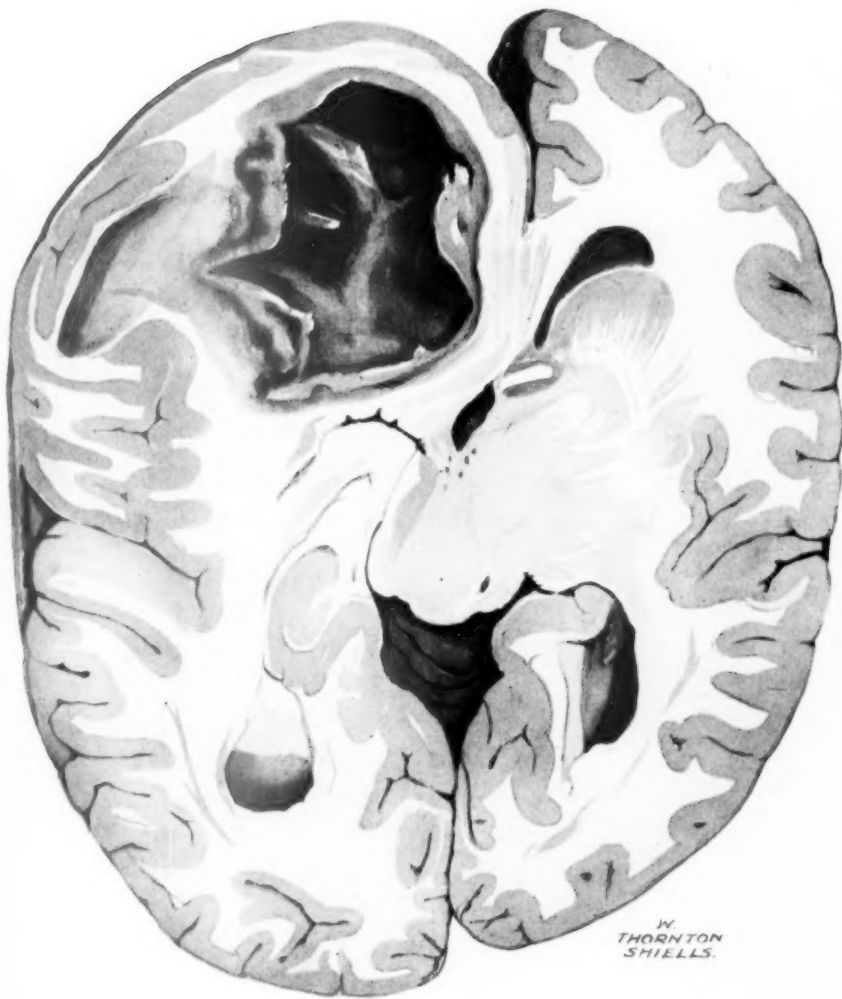
*Direct œsophagoscopy:* The entrance of the œsophagus is normal; the lumen about twice as wide as normal. The mucosa is whitish and macerated; no ulceration. No obstruction until 46 cm. is reached from the teeth (i.e. further down than the normal depth of the cardia). Here the lumen is abruptly terminated by a collection of four or five round, smooth, bright red masses, not friable, not ulcerated, not bleeding on contact. No lumen could be discovered; bougie dilatation not attempted.

*Biopsy:* Report by Dr. A. D. Fraser: "Portion of dermal tissue covered by hypertrophic (œsophageal) epithelium. There are numerous small spaces giving the appearance of lymph channels and a few muscle cells. The condition is lymphangioma. No evidence of malignant change.

April 12, 1934: Ten radon seeds (2 mc. each) inserted (0.5 mm. platinum screen).

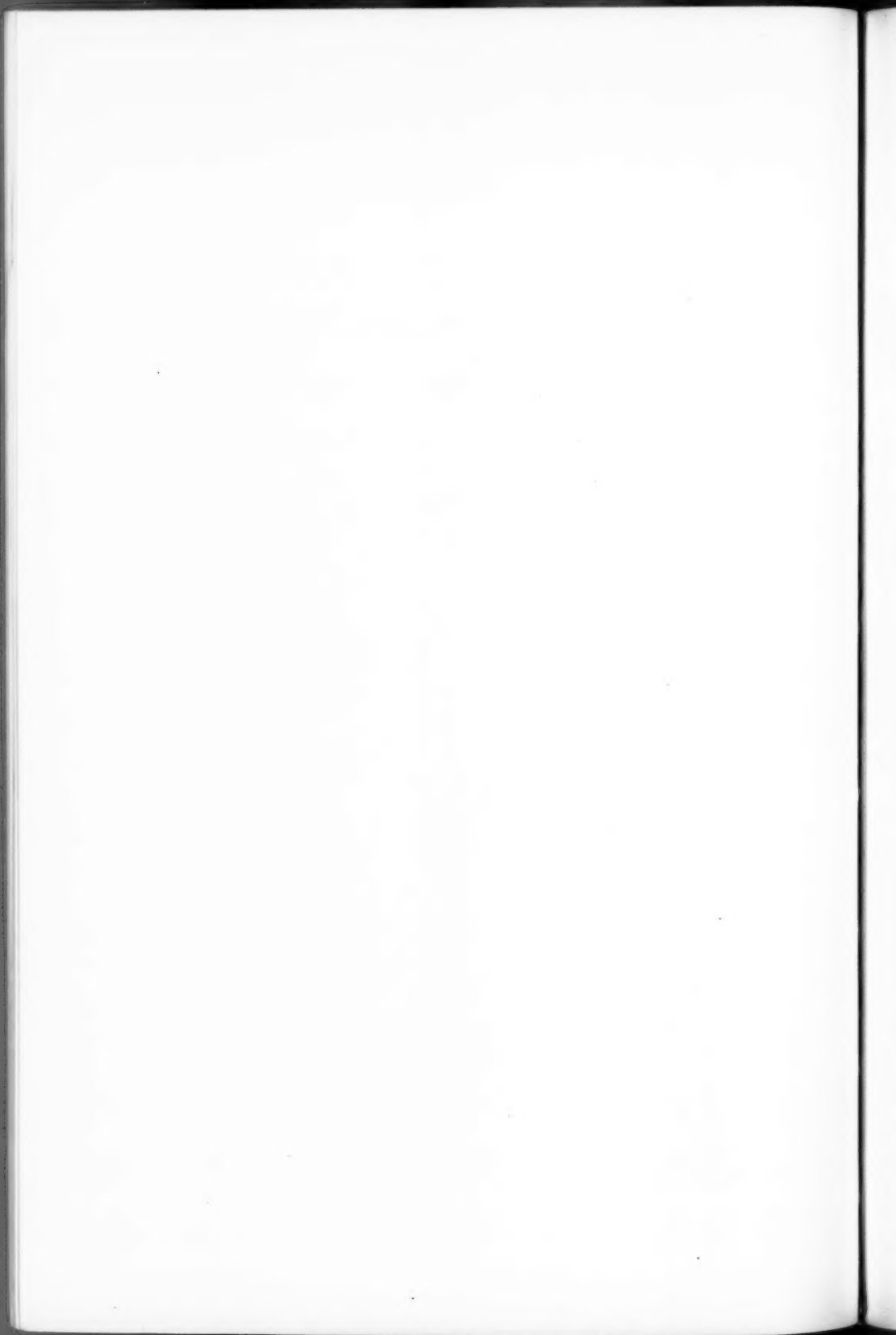
**POSTSCRIPT.**—June 20, 1934. Numerous nodules felt in the abdomen suggested that the growth is a lymphosarcoma with peritoneal secondaries. Swallowing is good for all foods but the patient is losing weight.

PLATE II



*John Bain Saxe & Enslin, 174 London.*

Large abscess in the left frontal lobe of the brain, arising from a foreign body in the nose (Charing Cross Hospital Museum).



## Section of Surgery

President—GEORGE E. GASK, C.M.G., F.R.C.S.

[April 4, 1934]

### Injection Treatment of Reducible Hernia

By ST. G. B. DELISLE GRAY, F.R.C.S.Ed.

[ABRIDGED]

MR. DELISLE GRAY described at length the history of the injection treatment of hernia and said that he himself used the method described by Dr. Ignatz Mayer, of Detroit, U.S.A., who claimed 98% of cures in all cases of reducible hernia treated by him. He continued:

The injection solution is made up as follows:—

Zinc sulphate	...	...	...	1 dr.
Phenol crystals	...	...	...	6 dr.
Glycerin	...	...	...	4 fl. dr.
Aq. cinnamomi	...	...	...	1 fl. oz.
Fluid ext. pinus Canadensis (dark)	...	...	...	5 fl. dr.
Sterilized chemically pure redistilled water	...	...	...	2 fl. oz.

It takes about a fortnight to prepare. I have it put up for me in clear glass, rubber-capped, one-ounce bottles. It is important to specify clear glass because the solution is muddy when cold, but on heating it becomes transparent, and if amber-coloured or other tinted containers are used it may be difficult or impossible to see when the fluid is clear.

When a herniated patient coughs he places his hand over the hernia in order to prevent the external oblique being separated from the internal oblique, thus allowing the hernia to "come down." This suggests that if we can by any mechanical means prevent the separation of the layers of muscle in the neighbourhood of the inguinal canal, we shall effect a clinical cure of hernia.

The injection of Mayer's solution, at intervals of four days, deep to the external oblique, causes a foreign body granuloma, which gradually fills up the inguinal canal, and by the subsequent contraction of the young scar tissues binds firmly together the three layers of muscle, and at the same time, compresses and obliterates the sac.

It is important to remember that the fluid is injected not *into* the sac, but *around* the sac. Throughout the whole of the period of treatment the patient must wear *day and night* a well-fitting steel spring truss of the rat-tail pattern, or with a perineal band, and this truss is only removed by the surgeon when he is about to make an injection, and is replaced by the surgeon when the injection is completed.

The total number of injections required is about twenty. At the beginning of the treatment the patient is shaved and placed on a couch (which must not be so short that either his head or his heels reach to one end of it), his pelvis being supported by a pelvic rest six inches high.

If the external ring is large enough, the skin of the scrotum is invaginated through the external ring by the third finger of the *right* hand if the operator stands on the *right* side of the patient, and with the same finger of the *left* hand if the operator stands on the *left* side of the patient, and the external oblique is lifted up and the needle No. 23 B.W.G., mounted on the charged syringe, is inserted until its point can be felt by the invaginating finger in the inguinal canal. When it is certain that the "eye" of the needle is not inside a vessel, a few drops of the solution are introduced, and finally the whole amount is slowly injected, the plunger being pulled back after every few drops, to make quite sure that the needle is still outside any blood-vessel. The needle is then rapidly withdrawn, the site dried with cotton-wool and dusted with talcum powder, and the truss re-applied by the surgeon, *the patient meanwhile resting quite flaccid*. This is a very important point, and is only with difficulty drilled into the heads of some patients.

If the external ring is not large enough to permit the skin being invaginated, the needle may be inserted through the external ring either above or below the cord, which is palpated and held out of the way.

This will occur after a few injections in all patients who have large rings, and is a most encouraging sign of progress.

As the treatment progresses a mass can be felt in the groin, increasing steadily in size, until finally it is impossible to invaginate the finger through the external ring and lift up the external oblique.

When the patient has had about twenty injections a hard mass can be felt in the groin, rather similar to what one feels after an ordinary operation for hernia, and the needle feels as if it is being inserted into rubber. The injections are now discontinued for a fortnight, and the patient is then examined lying on the couch as if for injection and, his truss having been removed, he is asked to cough. There should be no impulse seen or felt. The truss is then replaced, and he is re-examined in another fortnight's time; if there is still no impulse, he is examined standing, and he is then allowed to leave off the truss at night, and when he is having his bath.

He is re-examined a week afterwards, then a fortnight afterwards, and again a further fortnight afterwards, and then, if all is well, he is allowed to leave off his truss altogether, being examined at intervals of one week, two weeks and two weeks, to make sure that all is still well, and again after three months' and six months' intervals.

If he has to make any strenuous effort he is advised, as a matter of precaution, for the next few months or so, to put on his truss when about to make the exertion until he feels quite confident in himself.

Occasionally, when the needle is first inserted and the piston withdrawn, some coagulable fluid, which I believe to be peritoneal in origin, is drawn into the syringe. This probably comes from piercing the sac, which contains a small amount of fluid. The needle is then withdrawn and reinserted in a slightly different direction, as in experimental animals the injection of the fluid into the general peritoneal cavity has been followed by plastic peritonitis and death from acute intestinal obstruction.

Occasionally, also, on the injection of the first few drops, the patient has cramp-feelings in the hypogastrium or abdomen. In this case, probably, the point of the needle is just inside the general peritoneal cavity; the injection should be stopped at once, and the needle reinserted in a fresh direction. I have never seen any harm come from this, although there may be some discomfort for an hour or two afterwards.

There may be curious transient subjective sensations, such as burning of the scrotum or penis, or inner side of the thigh, or a sensation of warmth in the perineum or anus. These are of no untoward significance. Occasionally, a few seconds after the injection in the neighbourhood of the internal ring, there may be cramp in the distribution of the anterior crural nerve, followed by some paresis lasting a few days only.

If a vessel has been entered, the appearance of blood in the syringe on withdrawing the plunger gives due warning.

No case of new growth has been reported following on the artificial foreign body granuloma.

What are the advantages of this method of treatment? (1) There is no risk from anæsthetic or operation. (2) The treatment is entirely ambulatory, and there is thus no loss of time. (3) The pain and discomfort of the injection treatment are very much less than they are after operation. These three facts are very important from the patient's point of view.

According to those in other countries who have had experience running into thousands of cases, results compare favourably with operation. The injection treatment is counter-indicated in cases in which: (1) the hernia is not completely

reducible, or is complicated by imperfect descent of the testis, or some other condition making it impossible for the patient to wear a satisfactory truss; (2) there is active venereal disease, or any definite history of tuberculosis; (3) the intelligent co-operation of the patient cannot be relied on. For this reason I do not use the treatment in children; (4) the patient suffers from hæmophilia.

Mayer and others who have had extensive practice in this treatment claim about 98% of cures. I have no reason for doubting their claims, seeing that in my own series, the majority of which were extremely unpromising cases in which no self-respecting surgeon would care to operate, I have had 75% of absolutely satisfactory results.

I have not had the opportunity of seeing the pioneers at work and learning from them, and I have had to work out my technique for myself, but I can see no reason why, with further experience, my percentage should not rise much higher than it is at present.

### The Scope of Evipan Anæsthesia

By R. ATWOOD BEAVER, B.M., B.Ch.

THE material for this paper has been collected from about five hundred cases, chiefly from St. Thomas's Hospital. I am grateful to Dr. Z. Mennell, for permission to publish the results.

Evipan is given by intravenous injection and produces anæsthesia in approximately thirty seconds. Its action has been found experimentally to be on the metabolism at the base of the brain which is diminished [1]. The substance is detoxicated in the liver and is mainly excreted as urea [2]. No cases of renal or hepatic damage have been observed in this series.

The anæsthesia induced is variable both in duration and degree, and dosage must be arranged to suit each separate case. Only vague information can be obtained from the weight of the patient, but by making him count during the injection a fair idea of the anæsthetic dose is obtained. By giving as much again after his counting stops, satisfactory anæsthesia is generally obtained. Repeated doses can safely be given and this has been done with discretion up to four times. It will seldom be found that a normal adult requires less than from 7 to 10 c.c. The prone position and an assistant are essentials.

The advantages of evipan are :—

(1) *To the patient.*—Induction is absolutely smooth and pleasant and there is none of the "choking sensation" so often complained of by the nervous patient with inhalation anæsthesia. Recovery is equally pleasant, without nausea, vomiting or headache.

(2) *To the surgeon and anæsthetist.*—Evipan is convenient, portable and simple in use. The patient is always delighted with it and, with care, it is absolutely safe. The relaxation obtained is superior to that produced by gas-and-oxygen, and the absence of anæsthetic apparatus is a great advantage.

Unfortunately, the nature of the anæsthesia is very variable in duration and depth which cannot be predicted. Involuntary movements occur and need restraint. For long operations large doses must be employed and these are not without risk. Patients need to be watched when coming round, as excitement is prone to occur. Further, morphia should be given with discretion, as the respiration rate may be alarmingly reduced.

Evipan has been employed between the age-limits of 3 and 84. Absolute contra-indications seem to be gross renal or hepatic damage. Naturally evipan is not employed for moribund patients.

*Evipan may be used:* (1) Alone; (2) alone after premedication; (3) as an induction or basal narcotic; (4) for non-anæsthetic purposes.

. *Alone.*—(a) For minor surgery it is excellent, and comparable with gas-and-oxygen, but is more stable and simpler in use. The chief advantages are the absence of a gas-mask and the far greater degree of relaxation obtained. A minimum dose of from 3 to 5 c.c. only is necessary and out-patients may subsequently go home. They should, however, be allowed at least thirty minutes to recover, and any duty involving concentration (e.g. driving a motor car) is to be discouraged for at least an hour.

(b) For slightly more ambitious cases lasting from ten to twenty minutes—manipulations of large joints, total tooth extractions, &c.—it is extremely valuable. Three points should be remembered: (1) Time is strictly limited. (2) There is a time of optimum relaxation some two minutes after induction. (3) Incision will provoke involuntary movements, though there is excellent muscular relaxation.

(c) Used in large doses as a general anæsthetic, it tends to be less satisfactory, owing to its uncertainty. Operations involving the minimum of cutting are the best, and amongst these may be mentioned the following as satisfactory examples:—

Orthopædic manipulations, e.g. of the spine. Empyema, or drainage of larger abscesses. Trans-vaginal gynaecological operations. Bronchoscopy, œsophagoscopy or laryngoscopy. Operations on hæmorrhoids.

For abdominal operations it is not really satisfactory, owing to the involuntary movements and the large dose required.

• *After premedication.*—This is only safe at present with the morphia-hyoscine combination. Morphia, gr.  $\frac{1}{4}$ , or omnopon, gr.  $\frac{1}{8}$  with hyoscine, gr.  $\frac{1}{15}$  form an excellent preparation given three-quarters of an hour before operation. Deeper, smoother, and more prolonged anæsthesia is obtained, but its use is not entirely without risk. Care must be taken with the evipan doses, as the tolerance is definitely diminished and dangerous respiratory embarrassment may occur. The question has been discussed at length by Dr. Ronald Jarman and Mr. Lawrence Abel [3].

• *As an induction narcotic.*—Evipan for this purpose is excellent. It may be followed by gas-and-oxygen or ether, and has considerable advantages to the patient. As an adjuvant to gas-and-oxygen it acts as a basal narcotic, rendering anæsthesia very smooth. If a moderately large dose is given, the cough reflex will be absent or much diminished, and an intratracheal catheter may be introduced successfully.

As a basal narcotic analogous to avertin, it is of little value, because the length of amnesia is insufficient.

• *Non-anæsthetic uses.*—In the following cases evipan has been successfully employed for a purpose which is not strictly anæsthetic:—

(1) In a case of intractable sleeplessness in a patient suffering from pneumonia. Heroin having failed, sleep was successfully procured with 4 c.c. of evipan, and lasted four hours.

(2) For acute mania, given with morphia, gr.  $\frac{1}{4}$ .

(3) For the preliminary treatment of burns and the diminution of shock. During the initial cleansing before the application of tannic acid or other dressings (3-5 c.c.) will ensure the comfort of the patient.

(4) Subanæsthetic doses may be employed to produce a condition of "twilight sleep" in labour [4].

In each of these conditions only one or two cases have been treated, but the results seem to justify further use.

In this series there have been no fatalities and only two cases have caused real anxiety—which was not attributable, in either, to the anæsthetic. There have been no unpleasant sequelæ and only a few patients have shown excessive restlessness or prolonged sleep.

*Summary.*—Evipan is an excellent light anæsthetic, analogous to gas-and-oxygen and having considerable advantages. By means of premedication or large dosage

more ambitious operations may be performed, but it is doubtful whether in these cases the substance has any advantages over the old anaesthetics, except for induction. For really extensive operations the disadvantages appear considerably to outweigh the advantages and I feel that evipan is unsuitable.

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## Cysts of the Semilunar Cartilages of the Knee

By J. P. HOSFORD, M.S.

COMPARED with injuries to the semilunar cartilages of the knee, cysts of these cartilages are a rarity. Up to 1928 only about thirty cases of the condition had been recorded; since then, however, the number has increased considerably. As with many other conditions, it is impossible to estimate its frequency, because probably only a small proportion of all cases are recorded. Most orthopaedic surgeons meet perhaps one or two cases a year, but the general surgeon rarely sees one.

This peculiar cystic change in the semilunar cartilages is found about five times as frequently in the external cartilage as in the internal, and males are affected more commonly than females. It most commonly occurs between the ages of 20 and 30, although it has been recorded in patients over 50.

The clinical recognition and treatment of cysts of the semilunar cartilages are of interest and will be mentioned later, but the chief interest centres in their cause and pathology.

Macroscopically, after removal at operation, these cysts are almost always seen to be multiple. They are small in size, varying from that of a pin's head to that of a pea. They are deep to the capsule of the joint and involve and are attached to—in fact are part of—the semilunar cartilage. They are situated on the outer convex border of the cartilage, usually about half way along its antero-posterior length. When a cross-section of this part of the cartilage is examined the internal sharp concave border is seen to be normal and unaffected. As we follow the section outwards, the cartilage is a little thicker than normal, giving the appearance of being expanded, but having a softer central portion. In the outer part of the section of the cartilage a number of cysts are seen, bulging out into the surrounding tissues, as well as involving the cartilage. Some of the cysts are separated from one another by a definite thickness of cartilage, while others are so close together, being separated only by the thinnest membrane, that they might be called multilocular. The content of the cysts is a somewhat thick, mucoid, clear, colourless, or slightly brownish, material. The remaining portion of the semilunar cartilage, anterior and posterior to the part affected by cysts, appears to be normal, as do the adjacent articular surfaces of the tibia and femur.

The microscopical changes in a recent typical case may be described. Traced from the inner to the outer edges of the cartilage, we see normal fibrocartilage at the inner concave edge. Passing outwards, we come to a region where there are scattered areas of mucoid degeneration; a little further out may be seen a number of very small spaces with well-defined edges and containing material which takes up the hæmatoxylin stain—apparently mucoid substance. Further out are much larger spaces which are compressed and are the collapsed cysts, some of which were as large as a small pea and contained thick mucoid fluid [1]. There has been in the past a difference of opinion as to the nature of the cells which line these cysts in the cartilage, and as the cause and origin of the cysts depends, to a considerable

extent, on the nature of these cells I will take it as a reason for examining the point more fully.

Ollerenshaw and others have insisted that the cysts are lined by endothelium and believe that they are developmental in origin. Goldzieher describes them as being lined by a layer of flat cells resembling endothelial cells and probably arising from lymph vessels. Others deny that the cells lining the cysts are endothelial. A difficulty always liable to arise in studying microscopically a single layer of cells lining a cavity is that during the preparation and cutting of the section the cells may become detached and lost. However, in a number of published photomicrographs and drawings of sections of cysts of the semilunar cartilages, and in sections from a recent case, a layer of lining cells, at first sight resembling endothelial cells, is clearly seen. This, however, is only seen in the larger cysts. In the very small cysts no endothelial lining cells can be seen, although the cysts are still filled with mucoid material. It is difficult to imagine that a layer of endothelial cells could become detached from the cyst-wall during the preparation of the section and yet the mucoid contents of the cyst remain in position [2, 3]. Thus the larger cysts appear to have a lining layer of cells while the small cysts have not. The same observations as regards a true lining of cells in large, as compared with small, cysts have been made by Bristow. If the cells lining the cysts are studied carefully it may be observed that although they form a definite continuous layer, they are not typical endothelial cells, and that, moreover, when compared with the cells in the immediately adjacent fibrocartilage, they are seen to be extremely similar [4]. It is difficult to believe that these lining cells are a specific endothelium or that they are other than compressed cells from the surrounding fibrocartilage in which the cysts are situated. If there were an endothelium present, of developmental origin, one would expect not only to find it well-formed in the smaller cysts, but to find it showing even better than in the larger cysts, where it would be flattened-out owing to stretching.

Sections show no evidence of inflammation, or evidence of past hæmorrhage suggesting trauma.

Although it may be easy to say that the cysts are not of developmental origin, it is difficult to say what is the cause. What part does trauma play in their origin? This is a very difficult question to answer; the knee is so frequently strained or directly injured in both adults and children, that when any pathological condition arises in connexion with this joint, some recent or more distant trauma is usually readily recalled by the patient and blamed as the cause of the condition. If trauma were the cause, one would expect to find these cysts occurring more commonly in the much injured internal semilunar cartilage instead of there being a 5 to 1 preponderance in favour of the external cartilage. In many cases there is no history of any possible trauma, while in others symptoms are first noticed during a time of strain on the knee, and it is only in a very few that the condition dates from a definite injury.

Fisher believes that these cysts are ganglia, which originate between the peripheral surface of the external cartilage and the synovial membrane with which it is covered at this spot. It is difficult to believe that this is the true explanation, because sections show both mucoid degeneration and early cyst formation deep in the cartilage.

Cysts of the semilunar cartilages appear, therefore, to be the result of a mucoid degeneration commencing in the cartilage itself. Trauma plays a doubtful, if any, part in the onset of the condition, the cause of which is unknown.

Clinically there is a history of pain in the knee for a variable length of time. There is usually continuous discomfort in the knee, aggravated to actual pain by using it vigorously. In one case, for four years and a half the knee had been uncomfortable and the discomfort was increased to actual pain by—for example—running for

a bus; it would then last for about a day. There is usually no history of the knee locking. On examination there is, in the case of the external cartilage, a smooth tense swelling on the outer side of the joint just in front of the external lateral ligament of the knee. It is situated exactly on the joint-level and may be of any size up to that of a walnut. It is tender on pressure, and in some cases pain is caused by abducting the tibia on the femur, thus compressing the somewhat enlarged cartilage. In many cases the movements at the joint are full, though in others the last few degrees of flexion and extension are limited. In most cases the patient has noticed the swelling as a painful point, while in others he suffers pain without localizing it; it is in the latter case that the correct diagnosis may be overlooked if a careful examination is not made.

The treatment of cysts of the semilunar cartilages is removal not only of the cyst or cysts, but also of the major portion of the semilunar cartilage from which they arise. Failure to remove the cartilage is liable to lead to recurrence of the cysts. A satisfactory removal gives excellent results, with complete freedom from pain and a return to normal function.

## The Diagnostic and Therapeutic Uses of Thorium Dioxide

By A. E. PORRITT, M.Ch.

So accustomed has one become to accept recent advances in radiological technique as a most valuable means of assisting clinical diagnosis, that perhaps it is often not fully appreciated to what an extent it has now, in a relatively brief space of time, become possible to visualize practically all the principal organs and systems of the living body. In this short communication I wish to put before you a few facts concerning the latest method at our disposal, which makes possible the visualization of various organs and tissues heretofore beyond the scope of X-ray diagnosis.

In 1929 Oka discovered by chance that injection of a thorium solution into animals led to the production of subsequent X-ray shadows, chiefly of the liver and spleen. Paul Radt [1], in 1930, developed this finding and proved that thorium was taken up from the blood-stream by all the cells of the reticulo-endothelial system; and, that where these were concentrated in sufficient numbers—that is especially in the liver and spleen—it was possible, owing to the radio-opaque properties of the thorium, to visualize these organs.

*Properties.*—Radt evolved, for intravenous injection, a non-toxic substance known as "thorotrast," which is a stabilized 25% colloidal solution of thorium dioxide, diluted 1 in 10 with 5% glucose. It is an oily, opalescent, odourless liquid, easily miscible with all body fluids. Hence, apart from its use under discussion this evening, it is an excellent contrast-medium in practically any radiological sphere, being less toxic and more opaque than iodine. It has thus been used to advantage in radiography of the nervous [2], genito-urinary [3], and respiratory systems, of sinuses and fistulae, and in arteriography [4]. It is made by the firm of Heyden, and is obtainable from all the chief chemical firms in this country.

Injected into the blood-stream, it flocculates in about five minutes, and the minute flocculi are absorbed by the reticulo-endothelial system. In animals this allows visualizations, in varying degrees, of the liver, spleen, bone-marrow, adrenal cortex, lymph-glands, placenta, and ovary; kidney and lung shadows are also visible if these two organs are in any way diseased. Thorotrast is not picked up by the testis, or by malignant cells [5].

In man, to date, it has only been possible to obtain shadows of the liver and the spleen—hence the new term "hepatolienography." It is of interest to note that, while in animals the splenic shadow is predominant, in man the liver is definitely more distinct, the splenic shadow taking considerably longer to develop to anything like the same extent. The internal structure of the organs is not shown by this method, but it is possible, by using small dosage, to demonstrate outlines.

*Technique.*—Thorotrast is put up in 25 c.c. ampoules. Before use it should be warmed to body temperature, and the intravenous injection should be given very slowly; at least five minutes should be spent in giving the 25 c.c. This amount is approximately the maximum dose to be given at one time, and in itself will often be sufficient to produce a simple outline radiogram. To obtain the full shadow about 70 c.c. to 80 c.c. are required for an average adult, i.e. two further injections of 25 c.c. are given—in Germany, on consecutive days, in Canada and America usually with a two-day interval between doses, and in the two personal cases quoted later, with one-day intermissions. Even this dosage represents only 0·8 c.c. per kilo of body-weight, and 5 c.c. per kilo have been given to rabbits without ill-effect [5].

Films can, if required, be taken at any time after twelve hours from the injection, but the routine is from twenty-four to forty-eight hours after the last injection. The Potter-Bucky diaphragm is used. A high enema previous to the taking of the films is adopted as a routine measure in many clinics.

*After-effects.*—In most cases there are no immediate after-effects, though transient headaches, slight pyrexia, nausea, vomiting, and diarrhoea have all been reported in isolated instances. No change has been discovered in either blood or urine, and to the best of my knowledge no fatality has been reported. Actually, the effects of thorotrast injection would seem remarkably slight. Deliberate overdosage in animals produces a clinical picture resembling that of purpura hæmorrhagica.

The question of the later effects of this method is much more controversial, and centres in the fact that thorium is excreted extremely slowly. There seems a general agreement that in animals non-toxic doses produce no histopathological changes [6, 7], and that the thorium is excreted to some extent within a month, and to a considerable extent within six months. Dickson, Macdonald and Irwin, of Toronto [5], report their thorium animals fit and well at the end of a year after injection, and adduce evidence to prove definite excretion (particularly from liver and adrenal), via the lungs. The residual thorium particles appear to remain within the reticulo-endothelial cells concerned, as inert bodies, and no nuclear or protoplasmic damage has been detected microscopically.

Unfortunately in man, thorium cannot be so definitely acquitted of pathological effects. These may be briefly summarized as an early cloudy swelling in the organs concerned, followed later by a "foreign-body fibrosis." This conclusion was reached by Whitaker, Davis, and Murgatroyd [8] of the Royal Infirmary, Liverpool, though it is only fair to say that the German, American and Canadian schools are not in total agreement with it. However, as these deleterious effects appear to occur chiefly in toxic or cachectic patients, i.e. the very class in which such investigation is likely to be most frequently required, the method has, for the time being, in this country, been advocated for two types of patient only: (1) Those with obviously inoperable neoplasms; (2) those in whom an exact diagnosis might lead to such active treatment as would make a vital difference to the prognosis.

Thanks to the courtesy of Mr. Zachary Cope, I have had personal experience of two interesting cases of this kind:—

(I) The patient was a nurseryman, aged 43, who had lived all his life in the country and whose chief recreation had been regular cricket during the season. He was admitted to hospital in the middle of November 1932, complaining of abdominal pain first noticed three months previously. The only point of interest in his history previous to the onset of abdominal pain was an attack of so-called sciatica two months before. This had necessitated five weeks in bed, after which he had noticed painless swelling of the ankles. A fortnight before admission he observed unusual veins on his abdomen.

On examination these veins were very obvious, running laterally from thorax to groins. There was definite epigastric fulness, and abdominal respiration was limited. Palpation revealed a large epigastric mass, deep to the anterior abdominal wall, firm, sufficiently mobile to appear to move with respiration, not tender, and having no definite upper border. Percussion over this mass gave a dull note continuous with that of the liver.



FIG. 1.

Case I. Barium meal, showing forward displacement of stomach.



FIG. 2.

Case I. Barium meal, showing displacement of pylorus to left of vertebral column.



FIG. 3.

Case I. Showing thorium-filled liver indented by extra-hepatic neoplasm.



FIG. 4.

Case I. Showing flattening of indentation of liver after deep X-ray therapy.

A provisional diagnosis of carcinoma of the stomach with liver secondaries was made, and a barium meal was given. The report on this was that the stomach was displaced to the left, that the emptying time was delayed and that the pyloric shadows were deformed, suggesting a non-gastric origin for the tumour (figs. 1 and 2, p. 37).

The question now was whether the mass was hepatic or not, and a thorotrast examination was decided upon. Three doses of 25 c.c. of thorotrast, warmed to body temperature, were

injected intravenously, leaving one day between doses. Skiagrams were taken at intervals after injection, one of which is shown herewith (fig. 3).

Deep X-ray therapy was instituted immediately after this examination (December 20) and treatments given on four further occasions by the end of the month. The patient was discharged on January 10, 1933, the abdominal mass by then being hardly palpable (fig. 4). It seems reasonable to suppose that this somewhat remarkable result was due to the fact that the mass—presumably a retroperitoneal sarcoma—being almost surrounded by a thorium-filled liver, was exposed to an intensified radiation, thanks to the intrinsic radio-active properties of thorium.

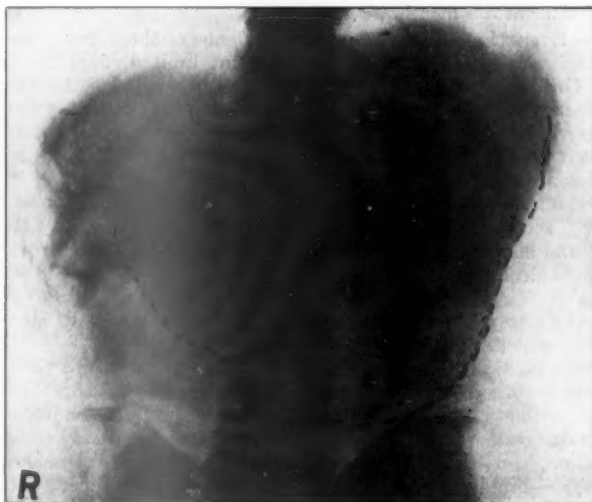


FIG. 5.

Case II. Showing enormous enlargement of left lobe of thorium-filled liver.

The subsequent history of this case was as follows:—

Readmitted February 1933, for a further course of deep X-ray therapy. Abdominal tumour impalpable. March 1933, hard, freely mobile mass of left supraclavicular glands appeared. Deep X-ray therapy was applied to these and to the abdomen.

In May and July 1933. Further X-ray therapy was applied, resulting in temporary diminution in the supraclavicular mass. Nothing was palpable in the abdomen.

The patient—unfortunately, from a scientific point of view—died in his own home in September 1933, and his local doctor reported that after an entire disappearance of the cervical glands, he rapidly went downhill and that towards the end his symptoms suggested mediastinal secondaries.

(II) The patient, a man now aged 56, was a historical case before he received thorotrast. His history was written up by Mr. Cope and Dr. W. D. Newcomb in the *British Journal of Urology* [9]. Briefly, it was that in 1920 (when aged 40) he was operated on for acute intestinal obstruction. Laparotomy discovered free fluid in the abdomen and a ring growth round the lower end of the ileum, there being multiple nodular small pelvic masses as well. The diagnosis being an inoperable neoplasm of the ileum, an ileo-transverse colostomy was performed. The patient did not progress favourably after the operation, but a course of selenium seemed to turn the tide in his favour. He gained 3 st. in weight in eighteen months and was then lost sight of, to reappear unexpectedly in 1928 at another hospital under Mr. Zachary Cope. He now had a testicular nodule, very suggestive of tuberculosis, and the original diagnosis was correspondingly altered. An orchidectomy was performed and a section of this (as well as of a pelvic nodule, one of the many still found to be present) showed a typical argentaffin tumour. Recovering satisfactorily from this second operation, the patient again became untraceable, only to reappear at a third hospital in April 1933

but once more under Mr. Cope's care. He now complained of a lump in the abdomen and on examination a large nodular fixed mass was found in the right iliac fossa and a still larger smooth tumour in the left epigastrium and hypochondrium. The question again arose as to whether this second swelling was hepatic or not—and if so, whether the enlargement was due to secondaries. A thorotrast examination was carried out, using exactly the same technique as in the previous case, and again not the slightest ill-effect was produced (fig. 5, p. 39).

Deep X-ray therapy was once more decided upon and repeated in August 1933. When last seen in December the patient's general condition was not quite so good, and he complained of anorexia and loss of weight. The ileo-cæcal mass was, if anything, larger, but the liver appreciably smaller than before thorotrast was given, though still obviously palpable. He is to have further treatment this month.

*Conclusion.*—Even the somewhat meagre evidence of these two cases seems to show that there is a most useful, though at present limited, field for this form of investigation. Until further clinical and post-mortem evidence is forthcoming as to the ultimate effects of the residual thorium in man, over considerably longer periods of time than have been reported to date, the method must of necessity be used sparingly. But in a case of necessity one has here a means of diagnosing hepatic and splenic lesions hitherto beyond the scope of investigation.

Apart from the value of being able to avoid unnecessary laparotomies in cases of malignant liver "secondaries," it has been possible to diagnose cysts, abscesses, hæmangiomas and cirrhosis of the liver, and infarcts, cysts, neoplasms and arterial thrombosis of the spleen.

Incidentally, it may be mentioned that useful and interesting physiological researches into the size and movements of the liver and spleen have also been made available by this method.

*Contra-indications.*—The immediate contra-indications—except perhaps marked hepatic and renal insufficiency (Kadrnka) [6] and its use in children—are extremely few; but if the ultimate effect is to be fibrosis of the reticulo-endothelial system with, as has been suggested, a subsequent "loss of phagocytic activity and inhibition of antibody formation," [8] the limitations of hepatolienography become very definite.

*Radio-activity.*—Finally, with regard to the radio-active properties of thorium: Despite the fact that most authorities [5, 6] on the subject agree that any action due to these is practically negligible, I cannot help feeling that in Case I, the effects of deep X-ray therapy on a mass almost surrounded by a thorium-impregnated liver, were enhanced to a very remarkable extent. Whilst this suggests possibilities in thorium therapy in selected cases, does it not also indicate that, in view of the almost permanent retention of thorium, its radio-active properties may have a definite effect over a long period on the tissues concerned? This viewpoint is strongly held by Jörg and Aguirre [10] who describe so-called "radio-active irritant" changes in six-month animals.

This problem, like several others connected with the method, can only be solved by further clinical and experimental research, and one is bold enough to hope that the discussion of these two cases may do a little towards stimulating such work, on a subject, which, though doubtless controversial, is of considerable interest and practical utility.

[I wish to express my keenest appreciation of their helpful reports and comments on cases and films to Dr. Courtney Gage and Dr. E. R. Williams.]

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## Section of Odontology

President—Sir NORMAN BENNETT, M.B., L.D.S.E.

[November 27, 19

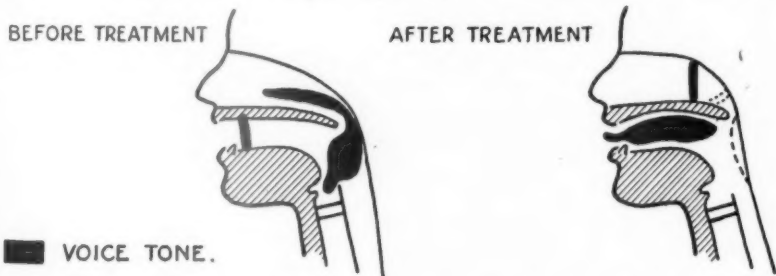
### Speech Training for Cleft Palate Patients

By FRED A PARSONS (introduced by Mr. HAROLD ROUND)

THE cleft palate patient, when he begins to speak, is faced with manifold difficulties which arise from three fundamental facts:—

- (1) Physical inability to obtain closure of the nasal passage.
- (2) The upper lip, in the case of a hare-lip, is too stiff to obey the commands of the mind; this stiffness prevents the lip from performing its normal function, i.e. the pulling of the voice-tone forward.
- (3) The lack of confidence, and sense of inferiority, which originate from the moment when the patient first realizes that he is different from—and unable to make himself understood by—those around him. As he grows up, he instinctively wishes above everything else to hide this difference; therefore for speech formation he uses the cloak of back articulation, employing muscles that are least noticeable in their movement. Thus we find the articulation, or meeting together of muscles to make speech sounds, in cleft palate speech, depends upon the movements of the pharyngeal wall, the soft palate, the hard palate, and the glottis; thus speech movement is pulled as far back as possible; this back muscle movement, together with the feeling of inferiority, tends to make the speech of these patients inaudible. The lips, tongue and teeth—the normal articulatory machinery, do very little speech movement, and therefore become lazy and disobedient.

These two diagrams show the position of voice-tone before and after treatment.



With these real speech difficulties it is not surprising that the patient feels inferior to his fellow beings, and this inferiority saturates his mind until it rules his thoughts and actions, crippling all mental and physical effort.

It has been said that "Speech is the trellis on which the mind climbs." If this support is inefficient, through inability, normal mental development is necessarily hindered, and the chief means of self-expression is denied. Many of my patients before treatment, find school, or any kind of social intercourse, a very real misery.

The cleft palate patient therefore—before operation or speech treatment—(1) is physically unable; (2) has no muscular control; (3) finds that the "tramlines" which carry the speech command to the normal speech machinery, are slow moving through little use; (4) is mentally unhappy through his inability to be understood.

After the physical inability has been remedied by the surgeon or dentist—by operation, or the making of a plate or obturator<sup>1</sup>—speech training is necessary in order to teach the patient:—

(1) The use of all the necessary speech machinery: (a) Lungs giving breath force; (b) strength of the larynx; (c) revitalizing of the tongue, lips, and jaw movement; (d) soft palate massage; (e) pharyngeal wall movement.

(2) The revitalization of tissue after operation.

(3) The use of a plate or obturator.

(4) The avoidance of nasal tone by redirection of breath flow.

(5) To have confidence and joy in speech movement, as, by the use of happy rhythmical exercises they lose the feeling of inferiority which constantly suggests inability.

With ability, control, and voice-tone the patients are able to take their place in the world, and I find that this realization of ability not only connects itself with speech movement, but radiates the mind and the patient thus becomes after treatment not only a normal understandable member of society, but also mentally more alert and able.

I have many examples among my own patients of increased mental alertness after treatment. Many have improved immensely in normal school work; one or two have obtained scholarships to secondary schools, and just recently one patient passed the matriculation examination.

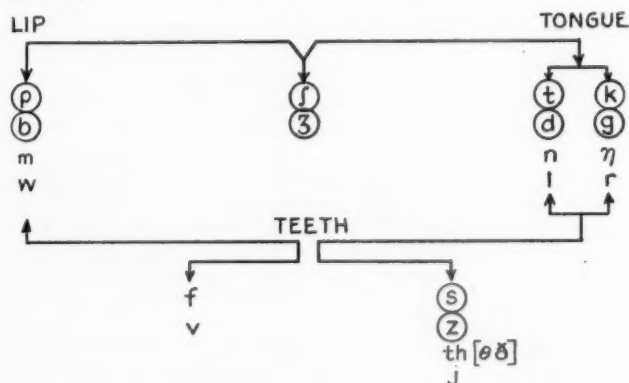
My speech exercises, therefore, whenever possible, are made into games, rhymes and word rhythms, and are carried out with energy, determination and concentration.

The exercises are divided into three groups:—

(1) The oiling of the speech machinery.

(2) The consonant and vowel formations are practised separately.

The ringed letters on this diagram show the sounds which the cleft palate patient finds most difficult.



S and z present the greatest difficulty, as these sounds, for correct formation, need complete nasal closure.

(3) Words and sentences. Rhymes for different sound constructions. Word rhythms. Games and competitions.

For all these exercises I use my own rhymes and word rhythms, which have now been arranged in book form. The forceful exercises have developed into blowing games—such as blowing rice from pipes, aeroplanes on to maps, swans on miniature

<sup>1</sup> My patients at the Children's Hospital have undergone the operation for closing the palate at a very early age—generally within the first year. At the Queen's Hospital the Billington-Round two-stage operation for closure is performed with excellent results on patients up to the age of 40.

lakes, little kelly dolls, miniature motors in races, and so on, together with many little home-made devices to help in various sound formations. Each week I endeavour to have a new game or competition; in this way keen excitement takes the place of what might become lifeless compulsory mechanical movement.

I feel that the aim in all this work should not only be to give speech clarity through the surface machinery oiling, but to penetrate into the minds and hearts of the patients instilling there a real sense of happy confidence in life, themselves, and their ability, until we all feel wholeheartedly that:—

Talking is fun! Talking is fun!  
But only if everyone—  
Can understand the words we say;  
So every day, and all day—  
We must use our machinery the right way!  
Then, to talk will be fun, really fun—  
For you, and me, and everyone!

[The paper was followed by a demonstration and a film. During the showing of the film each patient repeated separately a speech-training rhyme.]

### The Dental Aspect of Cleft Palates

By E. A. HARDY, M.R.C.S., L.R.C.P., L.D.S.E.

FOR the study of the dental aspect of cleft palates, I classify them into three main types—simple, compound and composite:—

(I) *Simple*: A cleft in the palate and no hare-lip. Here there is no dental irregularity (fig. 1).

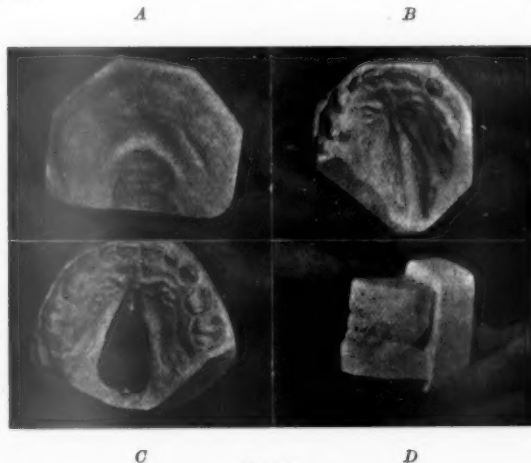


FIG. 1.

- |                                |                               |
|--------------------------------|-------------------------------|
| A. Before eruption of teeth.   | B. After eruption of teeth.   |
| C. With suture of soft palate. | D. Showing perfect occlusion. |

(II) *Compound*: A cleft palate and hare-lip. The hare-lip may be single or double. Here we have contraction of the dental arch and irregularities of the teeth, usually confined to the anterior teeth (fig. 2).

Types (I) and (II) refer chiefly to babies and children, and the following treatment is recommended for them: a hard vulcanite plate is made as soon as possible after birth and adjusted to fit the new conditions at the time of the lip operation. This is worn without pain or discomfort (figs. 5 and 6) and has the following advantages:—

- (1) It makes breast-feeding possible.
- (2) It acts as a comforter.

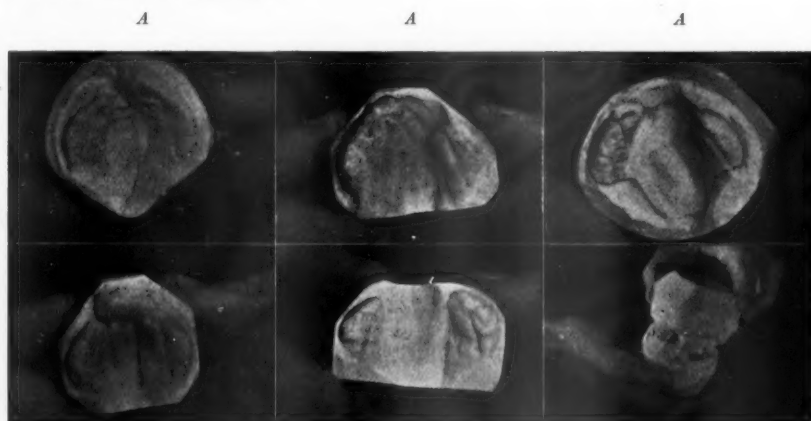


FIG. 2.

- A. *Single*. Before eruption of teeth, showing variations in size of alveolar cleft.  
 B. *Double*. Before eruption of teeth, showing variations in separation of maxillæ and forward displacement of premaxilla.  
 C. After eruption of teeth, showing lingual occlusion of anteriors.

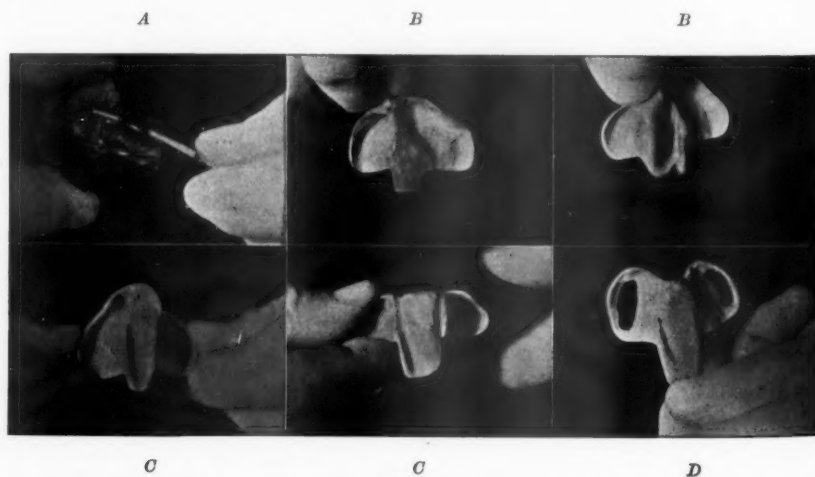


FIG. 3.

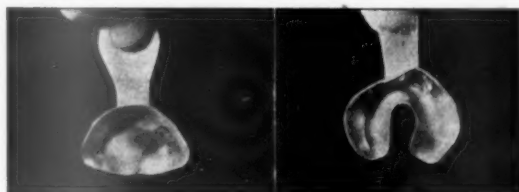
- A. Denture worn by Type I. B. Denture worn by Type IIA. C. Denture worn by Type IIB.  
 D. Denture worn by Type IIB to allow for erupting teeth.

(3) It prevents the spreading of the maxillæ.

(4) Sucking with the usual teat elevates the horizontal portion and creates a high vault and sometimes buckles the septum or retards its normal growth. This is prevented.

(5) With spoon-feeding air is swallowed with food. This causes indigestion and half an hour later the food is regurgitated. This is prevented.

In making plates for these babies one has to remember that sufficient nasal airway must be afforded. During the first two weeks of extra-uterine life, the babies cannot breathe through their mouths and any form of obstruction leads to death by asphyxia (fig. 3A). Turning from the practical side to the scientific, a controversy is still raging as to whether there is any loss of tissue in these clefts. Brophy and his satellites insist that there is none, but no dental surgeon on this or the other side of the Atlantic is inclined to support this view. The illustrations in



A

FIG. 4.

B

A. Stock tray reduced to baby size.

B. Special tray.



A

B

C

FIG. 5.

A. Double cleft before operation, sleeping with plate in.

B. Awake.

C. Feeding.

fig. 1 show that with the eruption of teeth there is perfect occlusion and yet loss of tissue in the palate. A comparison of the gum-pads at birth in these cases with those of the normal palate also tend to support this view. There may be some central organization which controls the growth of tissue whether soft or hard, but I cannot help thinking that there is some inherent virtue in normal cells themselves, whereby they can be stimulated to increase in size and number. The failure of the foetal processes to unite has robbed the tissues in the neighbourhood of the cleft, of the stimulus to increase, with the result that there is lack of tissue.

At a later stage, the cleft in the soft palate only is closed, as advocated by Sir Harold Gillies. This is better left until after the eruption of the temporary dentition so that a satisfactory plate can be made to elevate and push back the newly made soft palate (fig. 7).

I am not one of those who have been completely won over to the school of the Gillies-and-Fry movement to leave the hard palate severely alone. It was based on the surgery of two decades ago. The terrible results of surgery of those days are, I hope, a thing of the past. What the Gillies-and-Fry movement has taught us is that a good functional soft palate in a posterior position is the more essential aim of surgery.

The reasons for which I advocate a hard-palate closure are :—

(i) That plates have to be altered or remade during the eruption of teeth and the growth of the maxillary skeleton.

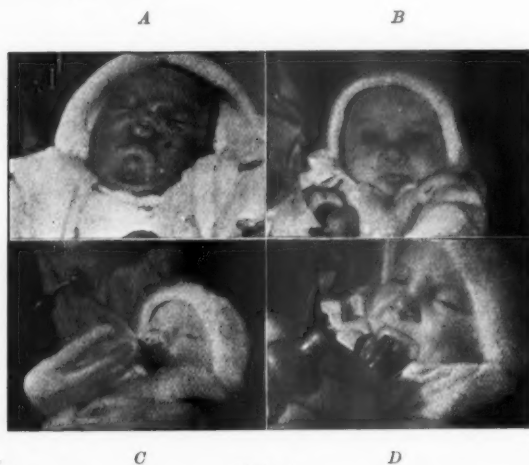


FIG. 6.

A. Double cleft before operation. B. After operation by Sir Harold Gillies.  
C. Feeding with plate in. D. Removing plate.



FIG. 7.

A. Showing contracted arch confined to anteriors. B. Denture to stretch and push forward upper lip and an adjustable and detachable portion to push and elevate soft palate. C. Patient blowing up balloon, showing that all oro-nasal, naso-pharyngeal and labio-nasal communications are sufficiently controlled. This patient has therefore perfect speech.

(ii) That patients are very fractious during this period and if a satisfactory plate is made with difficulty it is never worn. It is during this period that speech is being developed and speech training is impossible without closure by surgery or with a satisfactory plate. These are also the reasons for delay in the soft-palate closure, should this method be the one selected.

Before and after the lip operation, I have advised the use of the Poupon teat. This has proved very efficacious (figs. 5C and 6C). Norman Dodd, in a paper recently read before the Southern Counties Branch of the British Dental Association held at Southsea, has advocated a teat made on somewhat similar lines to the Poupon teat; but I prefer the Poupon, except that the additional valve in the other may be an advantage.

(III) So much for babies and children; we now turn our attention to adolescents and adults. These are the cases which comprise the *composite* type into which fall the majority of cases seen by the dental surgeon. They have the following characteristics: (a) The contraction of the dental arch is more severe. The contraction is no longer limited to the anterior teeth but extends to the premolars and molars (fig. 8). (b) Greater irregularity or loss of the anterior teeth. (c) Abnormality of the bite. Sometimes open (fig. 9B), sometimes closed (fig. 9A). (d) Malocclusion. All the teeth may be in lingual occlusion to the lowers, and the order

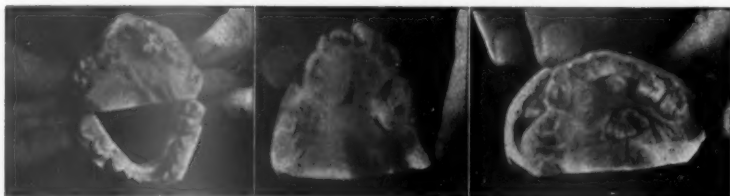


FIG. 8.—Type IIIC (i)



FIG. 9.

Type III. With closed bite A, open bite C and B, Type IIIA.

of severity is from the anteriors to the posteriors; but all the teeth can be in *complete* lingual occlusion. If there is post-normality, it is relative and due to the under-development of the maxillæ; for (e) The mandible is always fully developed. (f) The lower lip is often enlarged in an endeavour to meet the deficient upper.

Type III is subdivided into A, B and C.

(A) Successful closure of both hard and soft palates.

(B) Unsuccessful closure of hard palate with successful closure of soft palate.

(C) Successful or unsuccessful closure of hard palate with cleft in soft palate.

(A) Surgeons have attempted, and successfully secured in some cases, complete closure of the hard and soft palates (fig. 9C). The dental treatment, then, would be (1) orthodontic, (2) denture to supply missing teeth. The surgical treatment would be in aid of perfect speech. It will depend upon the proximity of the free posterior edge of the soft palate to the pharyngeal wall. Either of two methods or a combination of both can be adopted. The hard can be separated from the soft, the soft pushed back to meet the pharyngeal wall and the resulting raw area skin-grafted as recommended by Sir Harold Gillies; or a pharyngoplasty carried out as

recommended by Mr. E. Wardill, to bring the pharyngeal wall towards the soft palate.

(B) The dental and surgical treatment is the same as in the previous case except that a denture will have to be worn to cover the gap whether there be full complement of permanent teeth or not.



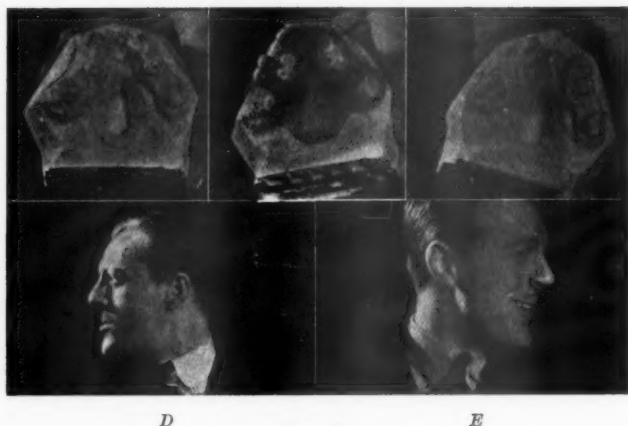
FIG. 10.

Facial appearance before and after insertion of denture.

A

B

C



D

E

FIG. 11.

Type III. A case showing teeth projecting through wax and in C, 54/45 have been prepared for gold crowns by a similar technique as that used for porcelain jacket crowns.

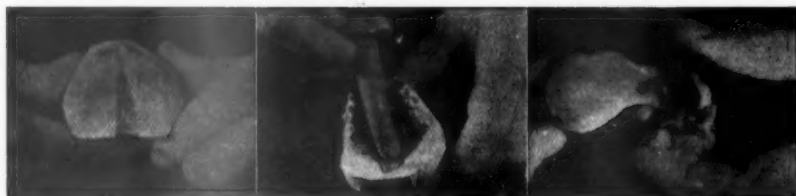
In this class are included those cases of subdivision (A) which have had the Gillies' operation (figs. 10 and 11).

If, however, the patient has reached adult life, the severity of the abnormal dental arch will determine the teeth to be extracted for the purpose of (1) closing an open bite, (2) interfering with the stability, insertion or withdrawal of dentures, (3) aiding speech by giving more room for the tongue.

In fig. 10 the teeth retained for support do not interfere to any extent with the concavity of the lingual surface of the plate. They are, therefore, completely boxed-in with their clasps. I advocate this to reduce the collection of food detritus around the necks of the teeth.

In fig. 11 the "lip-line" of the premolars is so low that the bulk of these teeth has been considerably reduced by the technique used in porcelain jacket crown work. These teeth are then capped by gold in such a way as to leave no "undercuts." No clasps are used in this case. All possibility of decay is entirely eradicated.

The position of the six fronts is determined by appearance (figs. 10, 11, 14), and assists in the pronunciation of such consonants as *S*, *D*, and *T*.



A

B

C

FIG. 12.

A. Type IIIc (iii).

B. Method of taking an impression of naso-pharynx in dentocoll.

C. Obturator of soft rubber.



A

B

C

FIG. 13.

Type IIIc (iii) showing patient with and without denture in position.

When the plate has to come in contact with an anterior edge of a free soft palate as in the Gillies' operation, certain points must be observed in the design of the denture. The mobility of the soft palate tends to upset the stability of the denture, and therefore that part which comes in contact with the free edge must be of soft rubber, as in fig. 10, or there must be some sort of spring attachment between the main body of the plate and that portion in contact with the free edge as in fig. 7. This same plate can be made to elevate and push back the soft palate (Fry).

(C) Into this class fall all those cases which need obturators. Some artificial means of aiding the closure of the nasopharyngeal valve is necessary. To do this, the impression should be taken in the fully contracted state. The material should not be too harsh so that it takes too much effort on the part of the muscles to shape, and yet it should be sufficiently fluid to take a sharp impression. This rules out gutta-percha and composition of any kind. It must not set too hard, because of the difficulty of removing it. It must not flow too freely, because of the possibility

of the patient swallowing the material, or being made to "gag." This rules out plaster. To my mind the ideal material is dentocoll, a material which satisfies all these points. After taking a rough impression, a vulcanite plate is made which roughly follows the contour of the valve and yet will not touch the walls in the fully contracted state of their musculature. By means of a rubber connexion fitted to the dentocoll syringe the impression material is made to flow through a hole previously made in the centre of that portion of the plate lying in the valvular opening (fig. 12B).

The act of swallowing tends to upset the stability of the denture as a whole. Therefore the obturator portion is fitted so that it can move during deglutition without moving the denture proper. This can be achieved by the use of soft rubber as in fig. 12C, or better still by a spring attachment as in fig. 14B. One's ingenuity can be used to devise a method of attachment between these two masses. These cases are further subdivided into: (i) Those in which the hard palate has been closed

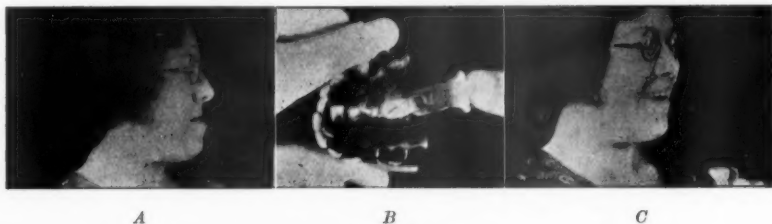


FIG. 14.

Same case showing posterior relationship of upper lip to lower and mobility of obturator attachment.

by utilizing the soft; (ii) Those in which there has been unsuccessful suturing of the soft palate; (iii) Those in which there has been no attempt at suturing.

The most difficult case to attempt to deal with dentally is the Type IIIC (i) case in which there is definite movement of a very deficient soft palate. If there is insufficient tissue to separate from the hard palate I recommend that the musculature be divided in the mid-line and the cleft in the soft palate returned to its original state. Those terrible results of surgery which are responsible for the majority of cases which fall into this subdivision are, I hope, a thing of the past. If I appear to be somewhat hypercritical of the surgery, I venture to put forward with all humility a plea of justification on the ground that a dental surgeon naturally becomes the surgeon's severest critic. He has to repair their failures, complete their successes and assist with apparatus some of their operations. He therefore sees the cases, before, during and after the repair. It is not the failures only that visit him. The ideals at which we aim are: perfect hard- and soft-palate closure, perfect occlusion, perfect speech and, last but not least, perfect appearance, i.e. to take away the stigma of a cleft palate facies. How far can these ideals be achieved when we consider that there is shortage of tissue to begin with? The number of surgical failures would appear to be considerably reduced by a two-stage operation such as the Billington-Round. The dental arch will become contracted, and too much stress cannot be laid on the necessity for orthodontia in early life. So great are the advances which have been made in orthodontia that "perfect occlusion" can be obtained and maintained. It would appear from the work of Miss Freda Parsons that "perfect speech" can be obtained by training, whatever the position of the soft palate, but I cannot help thinking that, however great the degree of success may be obtained in those cases in which the soft palate is in a very forward position, the time factor to produce these results must play an important part, as it must be easier to train a less severe deformity.

In what way is the dental surgeon called upon to assist speech? In the design of his dentures he can give the maximum amount of room for the tongue. He can make the lateral and antero-posterior curves of the lingual surface continuous concave curves (to lessen the possibility of the sound waves being broken). The design of artificial representation of the soft palate is important. And, lastly, in the position of the anterior teeth.

As regards the cleft palate facies, those beautiful operations for the alæ and columella deformities and the cupid's bow operations devised and ably carried out by Sir Harold Gillies and Mr. Kilner, leave little to be desired by the patients and their parents. Nevertheless the stigma does not wholly disappear until the aid of the dental surgeon is sought, to push forward the upper lip, and roll and evert the vermilion border. Every scrap of the dental surgeon's artistic skill and ingenuity is needed in placing those six upper fronts to give the effect of a pleasing appearance of the face—smiling, and in repose—both from the full-face and side-face aspects. In this respect the dental surgeon assists materially in influencing a change in the mental outlook on life from one of inferiority to one of self-esteem. This important factor is often overlooked.

I must express my gratitude to those who have assisted me in the production of the film, to the Kodak Company for their time, patience, and helpful suggestions, to the surgeons who have sent a sufficient number of cases to make the subject complete, and more particularly to Sir Harold Gillies, whose cases form the majority illustrated here. I cannot conclude, however, without paying tribute to all those whose ideas have been embodied in this paper, and I would mention, more especially, in this country, the work of Mr. Kelsey Fry.

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#### A Case of Geminated Second and Third Lower Molars.—HERBERT SMALE, M.R.C.S., L.R.C.P., L.D.S.E.

I do not think that a case of gemination of the second and third molars has been previously reported to this Section, nor can I find in dental literature any report of the gemination of these two teeth.

The patient, a medical student, aged 24, asked me to examine his mouth in the right lower molar region, because of considerable pain in that situation.

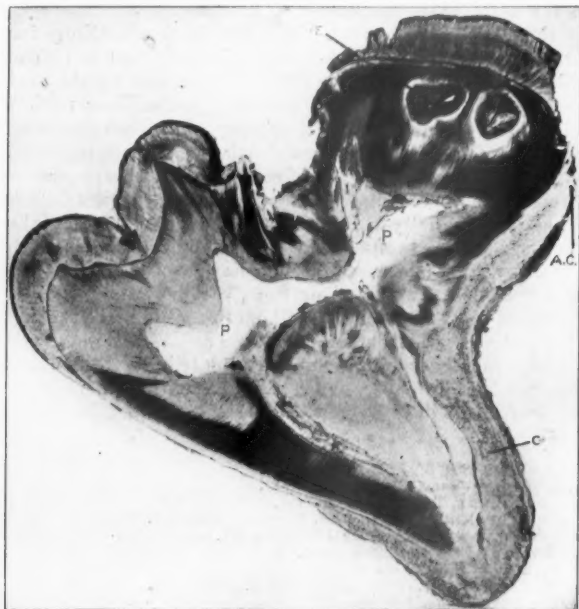
The third molar was apparently unerupted except for the mesial cusp, which was carious, and the pain was evidently due to pulpitis of this tooth.

A skiagram suggested impaction of the third molar, which appeared to be lying across the jaw. The second molar had a carious cavity distally, and the patient, who was going up for an examination shortly, preferred to have it extracted, together with the third molar, rather than to have the more elaborate operation of excision of a third molar alone.

My colleague, Dr. Wilfred Fish, operated in the Royal Dental Hospital In-Patient Department the same afternoon, as the case was urgent. It was fortunate that we had the patient's permission to do what we thought necessary, since upon attempting to extract the second molar, the whole geminated mass came away.

The photomicrograph shows that there is a combined pulp chamber at P, and the roots of the teeth are merged into one. The third molar crown is, therefore, merely a bud on the second molar. The enamel on the third molar ends very high up at the point A C, where a heavy deposit of cementum meets it. There are two

curious masses of enamel E in the dentine of the third molar, which appeared to be due to a tubular dipping-in of the enamel from the surface at some remote and undetermined point. The fold in the enamel which produced these masses is evidently more elaborate than a normal fissure.



The photomicrograph and the slide were kindly prepared for me in the Hampton Hale Research Laboratory at the Royal Dental Hospital.

[March 26, 1934]

**A Case of Multiple Dental Cysts.**—FRANK COLEMAN, M.C., L.R.C.P., M.R.C.S., L.D.S.E.

The patient, a man aged about 45, had three dental cysts—one in each upper jaw and one in the lower jaw on the right side.

Mr. Coleman said that the essential part of the treatment of a dental cyst was to open it in such a way as to leave a self-cleansing cavity, and to do this with the minimum amount of damage to the teeth and alveolar margins.

In his experience, in nine cases out of ten there was no distinct or tangible cyst lining to remove, and the inside of the cyst cavity felt much like the inside of an egg-shell; small portions of epithelium could, no doubt, be picked off, but this would serve no useful purpose. The after-treatment consisted in packing the cyst cavity for twenty-four hours, and afterwards irrigating at regular intervals.

Cysts which had suppurated for long periods often had a thick lining membrane, and under these conditions, as a rule, he removed the lining. A thick cyst lining could usually be enucleated by placing two or more pairs of pressure forceps on its free edge; on interlocking these and applying traction the cyst lining would come away intact. In employing this method it is necessary to define, by dissection, the free edge of the cyst lining before applying the pressure forceps.

